# CLOSING ECONOMIC WINDOWS:

## How H-1B Visa Denials Cost U.S.-Born Tech Workers Jobs and Wages During the Great Recession

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# Executive Summary

Tech giants like Google and Microsoft have come to define the communities in which they reside. These firms have transformed the regional and local economies around their headquarters, creating lucrative work opportunities, and contributing through tax revenues to improved public services like public education for the millions of people who live there. It's a story replicated by tech companies throughout the country in places like Washington, DC, Minneapolis, Tampa, and Austin. Since 2009, these cities have all experienced strong job growth and boasted some of the most robust figures in the country for the share of new jobs created that pay workers high wages.[1] This is due in no small part to the role of each city as a regional tech center and hub of innovation.

But for U.S. technology companies to continue to grow and create jobs in American communities, they need to have access to a sufficient number of workers. In recent years, many tech companies have reported challenges finding the workers they need with high-level training in Science, Technology, Engineering or Math (STEM) fields. In 2013, for instance, IBM, Intel, Microsoft, and Oracle had 10,000 open positions between them.[2] Such recruitment patterns are only expected to worsen in the coming years. By the end of the decade, the U.S. economy is expected to create 120,000 new jobs requiring a bachelor's degree in computer science each year. Yet our higher education system currently produces only 51,000 such graduates annually.[3]

Such large demand for STEM skills has led many companies to turn to immigrants to fill critical positions and keep important parts of their businesses operating on U.S. soil. Our country's broken immigration system, however, makes such a recruitment strategy difficult. Although foreign-born students on temporary visas earn almost 45 percent of STEM graduate degrees from America's most research-intensive universities,[4] there is no clear path for them to remain in the country after receiving their diplomas. And the number of visas available

through the H-1B visa program – the main visa used to bring in high-skilled, foreign-born, talent –is capped at 65,000 visas for private-sector workers each year. That number, however, often proves grossly insufficient.

In six of the last nine years, the H-1B visa cap has been met within 90 days of the government opening up the application window; and in 2007, 2008, 2013, and 2014, so many applications came in during the first week that officials had to hold a lottery to determine which ones to process. That meant that tens of thousands of potential workers were denied the ability to come to the U.S. After a surge of applications prompted yet another H-1B lottery earlier this year, some companies also looked to boost their presence in countries where, in some cases, visa availability makes it considerably easier to bring in high-skilled workers to supplement the local workforce. Microsoft, for instance, recently announced that it plans to increase its research and development capabilities in Canada. Microsoft's new office in Vancouver will create 400 jobs by 2015.[5]

Some policymakers, however, worry about whether relying on foreign-born workers here on U.S. soil might impact or displace tech workers born and trained in America. In this report, we examine this question using a uniquely strong research approach. Taking advantage of the randomness created by the 2007 and 2008 H-1B visa lotteries, we determine how the denial of H-1B visas for computer workers in that period impacted job and wage growth for U.S.-born tech workers in the years that followed. Our work relies on data from the United States Citizenship and Immigration Services, the U.S. Department of Labor, and the American Community Survey (ACS) to build a model that identifies causality much better than past studies on this topic have done before. The randomized sample also controls for all other economic factors—like population growth, foreign competition, and the underlying economic recession—that could have contributed to metropolitan job and wage growth during the time frame of the study.

The results of our analysis are clear. Cities whose employers faced large numbers of denials in the H-1B visa lotteries experienced considerably less job creation and wage growth for American-born computer workers in the two years that followed. Denying H-1B visas didn't help the economies of America's cities or their U.S.-born workers. Instead, it cost their tech sectors hundreds of thousands of jobs and billions in missed wages.

1  Richard Florida, The Atlantic, "The Boom Towns and Bust Towns of the New Economy"  (Sept. 18, 2013), available here: http://www.theatlantic.com/magazine/archive/2013/10/the-boom-towns-and-ghost-towns-of-the-new-economy/309460/.

2  Silicon Valley Leadership Group [Press Release], "Over 100 Leading Tech Executives Urge President Obama and Congress to Enact High-Skilled Immigration Reform" (March 14, 2013). Accessed May 14, 2014. Available here: http://svlg.org/over-100-leading-tech-executives-urge-president-obama-and-congress-to-enact-high-skilled-immigration-reform.

3  Cameron Evans, Madeleine McKenna, and Beneva Schulte, Educause Review Online, "Closing the Gap: Addressing STEM Workforce Challenges" (June 2013). Available here:  http://www.educause.edu/ero/article/closing-gap-addressing-stem-workforce-challenges.

4  U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System, 2009 data, compiled July 26, 2012

5  Email with Jack Chen, Senior Attorney, Labor Employment and Immigration Policy at Microsoft (May 22, 2015).

# Key Findings:

**The high number of H-1B visa applications that were eliminated in the 2007-2008 visa lotteries represented a major lost opportunity for U.S.-born workers and the American economy overall.**

The rejection of 178,000 H1-B visa applications in computer related fields in the 2007 and 2008 H-1B visa lotteries caused U.S metropolitan areas to miss out on creating as many as 231,224 often highly-sought after tech jobs for U.S.-born workers in the two years that followed. The total number of U.S.-born workers with computer-related jobs would have exceeded 2 million by 2010 with that additional employment.

**The U.S. tech industry would have grown substantially faster in the years immediately after the recession if not for the large number of visas that didn't make it through the 2007 and 2008 H-1B visa lotteries.**

The number of jobs for U.S.-born workers in computer-related industries would have grown at least 55 percent faster between 2005-2006 and 2009-2010, if not for the denial of so many applications in the recent H-1B visa lotteries. Our highest estimate shows that computer firms could have possibly added more than three times more jobs for U.S.-born workers than they actually did during that period without all the unsuccessful H-1B visa applications.

**U.S.-born workers without bachelor's degrees were disproportionately hurt by the H-1B visa lotteries in 2007-2008.**

Because less-educated tech workers often play valuable roles supporting the work of high-skilled engineers, programmers, and others, they were particularly impacted by the H-1B lotteries.  By 2009-2010, U.S. metropolitan areas lacked as many as 188,582 computer-related jobs for U.S.-born workers without a college degree as a direct result of the large number of applications that were denied in the 2007 and 2008 H-1B visa lotteries. The number of positions missing from the economy for U.S.-born, college-educated tech workers, in contrast, was between 24,280 and 42,642.

**The H-1B visa denials from the lotteries in 2007 and 2008 greatly slowed wage growth for workers in computer-related industries.**

In 2009 the 1.1 million U.S.-born, college-educated workers in computer-related fields missed out on nearly $3.0 billion in aggregate annual earnings as a direct result of the large number of unsuccessful applications in the 2007 and 2008 H-1B visa lotteries. From 2005-2006 to 2009-2010, wages for college-educated, U.S.-born workers with computer-related jobs grew by 1.7 percent. If the H-1B visas rejected in 2007 and 2008 visa lotteries had instead been approved, their wages could have grown by as much as 4.9 percent during that period.

**For some cities, the H-1B visa lotteries in 2007 and 2008 had a particularly large impact.**

In New York City and Northeast New Jersey, the large number of H-1B visas failing to make it through the lottery for workers in computer-related fields caused the local economy to miss out on creating as many as 28,005 jobs for native-born workers in those industries by 2009-2010. The Washington, DC metropolitan area, including parts of Virginia and Maryland, lost
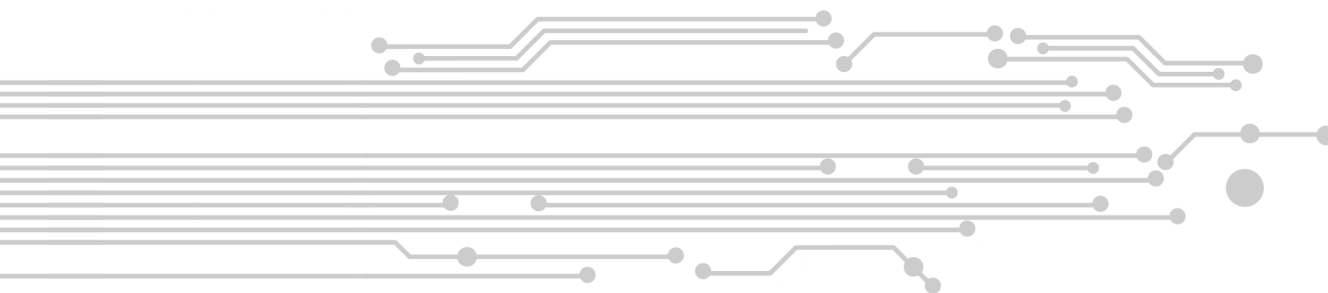
the opportunity to create as many as 30,222 computer-related jobs for U.S.-born computer workers during that period; Chicago and Dallas Forth Worth passed up the opportunity to create as many as 27,329 such positions together.

The findings of this study upend several narratives frequently advanced by opponents of immigration reform. Contrary to what some believe, high-skilled immigrants don't displace U.S.-born workers in computer fields. Instead, their presence spurs growth and creates more jobs – and higher wages – for native-born workers in the local tech industry. Our report also demonstrates that the country's broken immigration system—and its very real impact on technology companies—should be an issue of concern for policymakers from almost all parts of America. The 200-plus metropolitan areas examined in this report span 47 states—including smaller areas like Springfield, Illinois; Provo, Utah; and Corpus Christie, Texas—all of which had fewer computer jobs for U.S.-born workers and lower wages as a direct result of the H-1B lotteries in 2007 and 2008. An increasing number of industries also depend on workers with the sorts of advanced computer skills examined here, including banking and high-skilled manufacturing.

Whether the patterns outlined in this report continue, however, depends very much on Congress's action in the weeks and months ahead. In the last two years, the U.S. Senate and House Judiciary Committee have both passed bills that would raise the cap on the number of available H-1B visas for the private sector above 100,000 per year. They also have passed legislation that would grant green cards to foreign-born students receiving graduate-level STEM degrees from America's universities. Yet these are only half steps; real immigration reform has yet to pass through Congress. As this report demonstrates, easing the tech sector's

recruiting challenges would likely result in far more jobs for U.S.-born workers hoping to work in computer-related fields, arguably the future of the American economy. For now though, as gridlock in Washington persists, many Americans are denied such opportunities and the U.S. economy misses out on a valuable avenue for future growth.

# Part I: Introduction

At the start of this year's hiring season, Freescale Semiconductor, a technology company based in Austin, Texas, was preparing for a robust hiring season. The firm had offered hundreds of jobs to recent graduates of master's and Ph.D. programs in fields like chemical engineering, electrical engineering, and computer science at prominent U.S. universities. But hiring experts there quickly ran into a potential snafu: The limitations of the H-1B visa system. As is often the case in STEM graduate level programs, many of the students the firm hoped to hire were in the U.S. on temporary visas. The company applied for 108 H-1B visas to allow them to work for the next few years in America; A month and a half later, it appeared that only 76 of the applications had made it through a randomized visa lottery that would determine which H-1B applications the government would be able to process.

For a company like Freescale, such impediments can cause disruptions to business. "Our success really depends on finding high-skilled individuals who have the coursework to handle our complex products," says Nettie Luna, Manager of Immigration at the firm, "And when we go to our schools, many of the students we meet are from elsewhere." As a global firm, Luna says the firm will likely offer many of the workers unable to secure visas jobs in offices abroad. Some of their managers, however, are frustrated to be separated from promising members of their teams. Luna says the migration of those jobs abroad may also mean fewer jobs for potential U.S.-born employees that would have supported the new hires as managers, HR professionals, or secretaries at American offices.

In this paper, we set out to examine whether situations like the one faced by Freescale are having a broader impact on the U.S. economy and the ability of the tech sector to expand and create jobs for U.S.-born workers across the board. Researchers have long known that foreign-born, high-skilled workers play a valuable role contributing to America's competiveness and innovation. High-skilled immigrants are responsible for 26 percent of all of America's Nobel Prize Awards.[6] More than 75 percent of patents awarded to top U.S. research universities in 2011 also had at least one immigrant inventor.[7] In an era when many high-tech companies say they lack the high-skilled STEM workers they need, foreign-born workers also fill in gaps in the American workforce—helping companies continue to expand and maintain operations on U.S. soil.

Despite their many contributions, however, there remains some debate about how high-skilled foreign-born workers impact similarly skilled workers born in the United States. Although many studies have found a correlation between high skilled, foreign-born workers and increased productivity among U.S.-born, high-skilled workers—and the number of jobs available to them[8]—a handful of scholars have instead argued that

6  Jennifer Hunt and Marjolaine Gauthier-Loiselle (2010). "How Much Does Immigration Boost Innovation?" American Economic Journal: Macroeconomics, Vol. 2, pp. 31-56.

7  Partnership for a New American Economy, "Patent Pending" (June 26, 2012). Available here: http://www.renewoureconomy.org/research/.

8  Giovanni Peri, Kevin Shih and Chad Sparber, (2014). "Foreign STEM Workers and Native Wages and Employment in U.S. Cities,"NBER Working Papers 20093, National Bureau of Economic Research, Inc. and Petra Moser, Alessandra Voena and Fabian Waldinger, (2014). "German-Jewish Emigres and U.S. Invention,"NBER Working Papers 19962, National Bureau of Economic Research, Inc
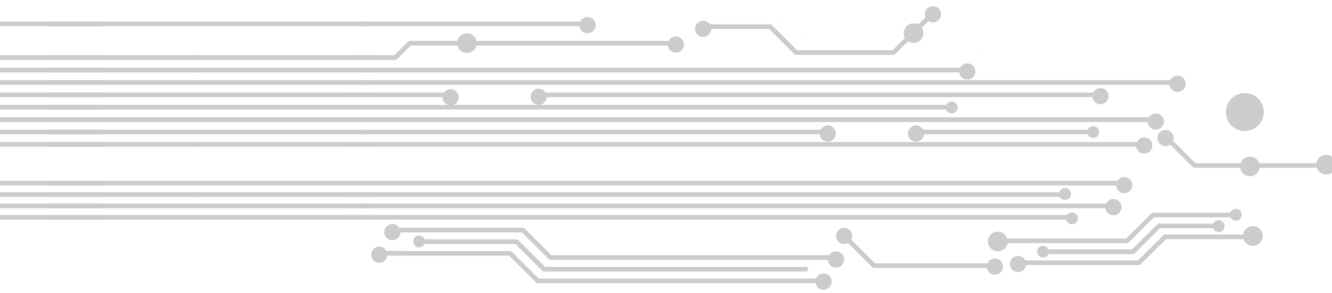
they displace such workers.[9] Most of the acrimony in the public debate and popular press regarding high-skilled immigration has focused on the H–1B visa program, a special visa available for temporary high-skilled workers, and whether the immigrants it allows to enter the country hurt the job prospects of U.S.-born individuals, particularly in the lucrative computer-related fields.[10]

The vast majority of scholarly articles examining the impact of H–1B visa holders have found no evidence that such workers crowd out employment or innovation. Still, drawbacks in the methodology used for those papers make it impossible to make such conclusions unequivocally.[11] The true innovation of this paper is that it leverages the natural experiment generated by the 2007 and 2008 H–1B visa lotteries to build a model that identifies the true causal impact that H–1B visa workers in computer-related fields have on U.S.-born workers living in the same metropolitan area and working in the same occupations—the very group that critics worry would be adversely impacted by an influx of foreign-born talent. To do this, we use data from the United States Citizenship and Immigration Services and the U.S. Department of Labor to calculate how the demand for computer workers in 236 metropolitan areas across the country went unmet as a result of the 2007 and 2008 H–1B visa lotteries. We then use data from the American Community Survey to examine how that unsatisfied demand for workers impacted the number of jobs created for U.S.-born computer workers and the wages paid to them in the two years that followed. [For more details on the exact calculations and data sources used, see the Methodology Appendix.]

Our findings present clear evidence of the powerful impact that H–1B workers have on the growth of tech sectors in American cities. In areas that had a large number of unsuccessful H–1B lottery petitions relative to the size of their computer workforce in 2007 and 2008, the expansion of the tech sector and the growth in wages paid to local computer workers slowed considerably. In Washington, DC, the large number of local H–1B visa applications that didn't make it through the lottery caused local companies to lose out on creating as many as 30,222 computer jobs for U.S.-born workers in the period between 2005–2006 and 2009–2010. By 2010, U.S.-born computer workers there also missed out on as much as $519 million in additional wages as a group. In Dallas–Fort Worth, as many as 10,687 fewer such jobs were available. For less-skilled workers in particular, such job creation effects lingered three years after the visa lotteries—showing the lasting damage our country's broken high-skilled immigration system does to city-level economic growth and the ability of metropolitan areas to provide desirable tech jobs to their residents.

At Freescale, Nettie Luna says she worries about how the H–1B visa program may impact her company and city in the coming years. Luna says Freescale will likely apply again next year for visas for employees that didn't make it through the lottery this year. The company will also likely be submitting new applications for any foreign-born students they try to recruit for their Texas or Arizona offices next year. "I worry that this problem will just grow larger if nothing happens," she says, "Instead of 32 rejections, we could face 62 next year." It's hardly a way to pay back a firm trying to rapidly expand jobs and opportunities here in America. Says Luna, "It's all incredibly frustrating."

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9  Borjas George J. and Kirk B. Doran, (2012). "The Collapse of the Soviet Union and the Productivity of American Mathematicians," The Quarterly Journal of Economics, Oxford University Press, Vol. 127(3), pages 1143-1203.

10  See: Matloff, Norman (2008) "H-1Bs: Still Not the Best and the Brightest," Center for Immigration Studies Backgrounder; and Hira, Ron (2007) "Outsourcing America's Technology and Knowledge Jobs: High-Skill Guest Worker Visas are Currently Hurting Rather than Helping Keep Jobs at Home." Economic Policy Institute Briefing Paper no. 187.

11  This is because prior papers have relied on pre-existing variation in demand for foreign skilled workers across labor markets (metropolitan areas) interacted with aggregate flows of skilled immigrants or with changes in policy (the cap of new H-1B issuances allowed, for instance). Strong persistence in unobserved demand shocks for highly skilled workers could generate a positive spurious correlation between foreign and native-born outcomes, which would bias models against finding crowding-out.

# Part II: Background

## THE H-1B PROGRAM AND RECENT LOTTERIES

Since its creation in 1990, the H-1B visa program has been the main method of U.S. workforce entry for foreign-born, college-educated professionals—especially scientists and engineers pursuing work in computer-related fields. Since the beginning of the program, the number of visas awarded each year has been subject to an annual quota. Initially capped at 65,000, Congress raised the cap to 115,000 during the tech boom in 1999 and then to 195,000 for the 2001 to 2003 period. In 2004, it once again reverted to 65,000, with an additional 20,000 visas reserved for workers who have earned a master's degree or Ph.D. from a U.S. college or university. The lower cap on the total number of visas has put a particular strain on businesses in the last decade: Every year since 2004, the cap has been met before the close of the fiscal year. In many cases, it was exhausted in less than a month.

Several steps are required for an individual to acquire an H-1B visa—and all are relevant to the data sources used in our research. A firm wishing to hire a foreign-born specialty worker must first file a Labor Condition Application, or LCA, with the U.S. Department of Labor. This document outlines the nature of the job and attests that the firm will comply with H-1B regulations. The form includes information on the prevailing wage of the occupation, the wage to be paid to the prospective worker, and where the work will occur. Since the visa is temporary in nature and lasts for three years (and is renewable once), the LCA must also provide the beginning and end dates of the position. A prospective H-1B visa holder applies for an H-1B visa using an I-129 form, a document submitted to US Citizenship and Immigration Services. To apply, he or she must have a job offer from a firm that has already applied for—and secured—an approved LCA.

To understand the full magnitude of the recent H-1B visa shortage, it is useful to have some background on the timing of the visa application process. USCIS begins accepting H-1B applications beginning on April 1, six months prior to the start of the fiscal year on October 1—the first day of the year a new H-1B visa holder can start working. Similarly, The Department of Labor will also not consider any LCAs until six months before a worker's intended start date. In the years before 2007, this meant that employers would frequently submit their LCAs on April 1, receive approval soon afterwards, and then submit an I-129 in May or June, with the expectation it would be approved before a worker's October start date. In other cases, with less of a rush to obtain visas, employers would be able to hire H-1B workers to start at any point year round.

Acute scarcity of visas induced a peculiar behavior in calendar years 2007 and 2008, however. Firms began to "predate" their LCAs. For example, they would file an LCA in March of 2007 claiming an intended start date of September 2007, but knowing that a new H-1B recipient would not be legally able to begin work until October 2007. Firms did this because they worried if they submitted the LCA application in April—and then waited for that approval before filing for the H-1B—they would not necessarily get the visas before the small pool of available H-1B visas were exhausted. Submitting their LCA in March, however, came at a cost to potential employers: Because LCAs only remain valid for three years, firms sacrificed a month of work from their H-1B workers at the end of their government-approved work period.

Figure 1 illustrates the marked difference in for-profit firm behavior that emerged in calendar years 2007 and 2008. In those years, the submissions of H-1B applications became highly concentrated: More than a quarter of all LCAs were filed in March with "intended" September start dates. By comparison, in 2006, only 2.5 percent of LCAs in 2006 were filed during that month. This behavior resulted in USCIS receiving an unprecedented 119,193 H-1B applications for private sector workers in the first week of the application window in 2007. In 2008 that figure climbed to 163,000.[12] As a result, in 2007 and 2008 USCIS used a lottery to randomly select private-sector visas for processing until it reached the 65,000 cap. Immigrants who had hoped to file applications in later months were shut out of the process all together.

As the number of applications was roughly double the number of granted visas, this process induced a rationing of foreign-born, high-skilled immigrant workers that was both significant in size and randomly distributed among applicants. Throughout this paper, we frequently use the term "H-1B supply shock" to describe how the H-1B lotteries of 2007 and 2008 impacted individual metropolitan areas. To understand this term, it's useful to consider how the denial of 500

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12  See "USCIS Updates Count of FY 2008 H-1B Cap Filings," US Citizenship and Immigration Services, April 10, 2007; and "USCIS Runs Random Selection Process for H-1B Petitions," US Citizenship and Immigration Services, March 31, 2008 (date on press release is clearly wrong).

visas might impact two very different cities. In a large metropolitan area like Los Angeles, which provided jobs to close to 90,000 computer workers in 2005–2006, the rejection of 500 H–1B visas in the 2007 lottery would be a relative insignificant occurrence. In a metropolitan area with a much smaller tech workforce, however, like Abilene, Texas, which had just 244 computer workers in 2005–2006, 500 unsuccessful visa applications would be a much more dramatic event. Had those visas been approved, the computer workforce in that area would have more than tripled simply due to the arrival of those foreign-born workers—not even counting

any additional employment their work would have generated in the years afterwards.

In light of those considerations, our paper uses the measure of an "H–1B shock" to determine whether a city had relatively good or bad luck in the H–1B visa lotteries of 2007 and 2008. In the report, this figure is calculated by dividing the number of local, H–1B visas that didn't make it through the lottery by the number of computer workers in an area pre-lottery, in 2005–2006. We show the figure as a percentage. In the hypothetical example above, for instance, Los Angeles experienced a

## FIGURE 1:

**Fraction of Labor Condition Applications by Month of Submission, 2005-2008**

.5 percent H–1B shock (or 500/90,000). In other words, Los Angeles's computer workforce would have grown by .5 percent had the visas in that didn't make it through the lottery had instead been approved. The average city in our sample experienced an H–1B shock of 4.1 percent. Nine metropolitan areas experienced an H–1B shock of 10 percent or more—including Washington, DC; Wilmington, Delaware; Springfield, Illinois; and Davenport, Iowa. (See Table 1.)

In this study, we follow what happened to the U.S.-born tech workers in cities that received large negative shocks—or had bad luck in the H–1B lottery. By comparing that data to outcomes in cities that had comparatively better luck, we can track the causal effect that the negative supply shock had on U.S.-born workers in computer-related fields in the years that followed.

## TABLE 1:

**Metropolitan Areas that Experienced the Largest H-1B Shocks in the 2007-2008 Period**

| Metropolitan area | Total Computer Industry Employment, 2005-2006 | Average Number of H1B Visas Denied per Year 2007-2008 | Size of H-1B Shock |
|---|---|---|---|
| Trenton, NJ | 6,148 | 2,280 | 37.1% |
| Wilmington, DE/NJ/MD | 7,052 | 1,345 | 19.1% |
| Manchester, NH | 715 | 106 | 14.8% |
| Detroit, MI | 40,366 | 5,386 | 13.3% |
| Davenport, IA-Rock Island -Moline, IL | 1,941 | 255 | 13.1% |
| Worcester, MA | 3,920 | 482 | 12.3% |
| Washington, DC/MD/VA | 132,901 | 14,060 | 10.6% |
| New York-Northeastern NJ | 168,330 | 17,104 | 10.2% |
| Springfield, IL | 698 | 70 | 10.0% |
| Portland, ME | 2,788 | 250 | 9.0% |
| Nashua, NH | 3,597 | 313 | 8.7% |
| San Jose, CA | 54,001 | 4,641 | 8.6% |
| Danbury, CT | 2,316 | 194 | 8.4% |
| Chicago, IL | 89,503 | 7,410 | 8.3% |
| Stamford, CT | 4,376 | 292 | 6.7% |
| Atlanta, GA | 65,672 | 4,346 | 6.6% |
| Akron, OH | 5,944 | 345 | 5.8% |
| Louisville, KY/IN | 6,300 | 315 | 5.0% |
| Pittsburgh, PA | 16,858 | 830 | 4.9% |
| Dallas-Fort Worth, TX | 80,640 | 3,820 | 4.7% |
| **Total All Metro Areas** | **2,1888,258** | **88,693** | **4.1%** |

## THEORIES ON HOW H-1B VISA HOLDERS INTERACT WITH THE U.S. HIGH-SKILLED WORKFORCE

To understand what sort of outcomes we might see in the data, it's useful to consider two different scenarios involving the possible role of foreign-born high-skilled workers in the computer workforce. In a situation where high-skilled, foreign-born, workers are being hired even though similarly qualified, U.S.-born workers are available, we would expect a sudden shock in the supply of H-1B workers to cause employers to promptly hire local, U.S.-born workers instead. In this case, the employment of U.S.-born, computer workers would rapidly rise in metropolitan areas that had bad luck in the H-1B visa lottery. We would also expect to see the wages of those U.S.-born, high-skilled computer workers go up as well, reflecting the fact that their skills are now in shorter supply. Less-skilled workers playing support roles would potentially be relatively unaffected by such a situation: They would still be supporting the same number of workers. The only difference would be that the high-skilled employees would be U.S.-born instead of foreign-born.

A second scenario paints a starkly different picture. In this environment, instead of H-1B workers being substitutes for available American ones, they are complementary to them. These foreign-born workers contribute unique skills or fill different roles in the computer-related firms that hire them. Their work, in some cases, results in innovations that raise corporate revenues overall, or allow firms to pursue new lines of business. By potentially contributing to innovations that save the firm time and improve performance, these workers also have the potential to contribute to increased productivity in the workplace. In this scenario, a sudden decrease in the supply of H-1B workers would lead computer-related firms to grow more slowly in the coming years and potentially scale back their ambitions in the more immediate term. This would cause the growth of new jobs created for U.S.-born workers in the computer-related industries to slow down as a result of the lottery. Wage growth would slow as well, as workers faced a less robust market for their services.

It is important to note that our work analyzes just a subset of the H-1B visas that were processed through the 2007 and 2008 visa lotteries. In those years, USCIS granted 65 percent of the H-1B visas subject to the 65,000-per-year cap to workers with jobs in computer-related industries. (See Table 2.) Similarly, 63 percent of the LCAs filed by employers in those years were for

jobs in those fields. Foreign-born workers also represent a significant share of workers in computer-related occupations in the country generally. In the 2005 ACS, nearly 25 percent of computer-related workers in the U.S. metropolitan areas were foreign-born. All of these factors make this segment of the working population particularly ripe for an analysis of this sort. Unlike industries like journalism, where H-1B workers have a small presence and the lottery likely had a minimal impact, computer-related employers were hit hard by H-1B denials in 2007 and 2008. Such employers also exist in large number. These factors allow us to make stronger conclusions about the impact of the H-1B lotteries; it also allows us to focus on observations where the margin of error is relatively small at the metropolitan-area level.[13]

Our work also breaks down all employment and wage growth data to consider the impact the H-1B lotteries had on U.S.-born tech workers both with and without college degrees. While many Americans think of computer-related industries as employing mostly high-skilled workers, a substantial number of less-skilled individuals also work in the field: In 2006, about two out of every five U.S.-born individuals working in technology did not have a four-year college degree— at most they had only some college education. For our purposes, it is useful to look at these two groups separately. Critics, who worry that H-1B workers displace American high-skilled workers, would expect U.S.-born, high-skilled computer workers to benefit when they have fewer foreign-born programmers and computer experts to compete with. By breaking the two groups down separately, we are able to show clearly that this is not the case.

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13 Extending the analysis to other fields results in small occupation-by-metropolitan area cells with large measurement error and very large amount of noise so we elected not to pursue that avenue.

## TABLE 2:

**Number of Cap-Dependent H-1Bs Granted by Occupation, April 2007 and April 2008**

| Occupation Group | Average Employment, 2005 & 2006 | | Cap-Bound H-1B Visas Awarded, April 2007 & 2008 | |
|---|---|---|---|---|
| | Number | Percent | Number | Percent |
| Computer-Related Occupations | 2,227,420 | 3.22% | 77977 | 65.11% |
| Managers, Officials, and Occupations in Administrative Specializations | 15,318,099 | 22.14% | 13778 | 11.50% |
| Occupations in Architecture, Engineering, and Surveying | 1,595,252 | 2.31% | 13476 | 11.25% |
| Occupations in Medicine and Health | 3,228,074 | 4.67% | 3127 | 2.61% |
| Occupations in Mathematics and Physical Sciences | 774,037 | 1.12% | 2271 | 1.90% |
| Occupations in Social Sciences | 143,100 | 0.21% | 2218 | 1.85% |
| Miscellaneous Professional, Technical, and Managerial Occupations | 391,230 | 0.57% | 1985 | 1.66% |
| Occupations in Art | 426,014 | 0.62% | 1450 | 1.21% |
| Occupations in Life Sciences | 248,650 | 0.36% | 916 | 0.76% |
| Occupations in Law and Jurisprudence | 974,778 | 1.41% | 789 | 0.66% |
| Occupations in Education | 3,247,468 | 4.69% | 604 | 0.50% |
| Miscellaneous | 517,746 | 0.75% | 513 | 0.43% |
| Occupations in Writing | 207,505 | 0.30% | 387 | 0.32% |
| Occupations in Entertainment and Recreation | 127,576 | 0.18% | 133 | 0.11% |
| Occupations in Religion and Theology | 260,500 | 0.38% | 82 | 0.07% |
| Occupations in Museum, Library, and Archival Sciences | 106,016 | 0.15% | 51 | 0.04% |
| Occupations Not Valid for H-1B Program | 39,395,775 | 56.94% | 0 | 0.00% |
| **Total** | **69,189,240** | **100.00%** | **119,757** | **100.00%** |

Note: H-1B data are from the USCIS and include our estimate of all new H-1B issuances subject to the cap, April 2007 & 2008. Estimates exclude workers from Australia, Canada, Chile, Mexico, and Singapore, who have methods of entry to the US workforce that are not subject to the H-1B lottery. Employment data are from the 2005 and 2006 ACS and include full time employees. The table describes visas and employees in metropolitan areas only.

# Part III: The Employment Effect

In recent years, despite the lingering effects of America's economic recession, computer-related industries in the United States have enjoyed a fair amount of employment growth.  Between 2007 and 2011, the U.S. has added 168,000 new jobs for workers in computer-related fields. Still, a large number of industry leaders say that America's broken immigration system has limited what their companies have achieved and put a constraint on the jobs they have been able to create. Many firms say their difficulty in recruiting adequate talent slows down expansion and possibly other measures of success like innovation and patent generation. Other analysts say that other issues with our immigration system —such as America's lack of a workable start-up visa—keeps companies and entrepreneurs from coming to the U.S. in the first place.

In this section, we aim to quantify how one small subset of the immigration problem—the restricted number of H-1B visas available to employers—has impacted job creation for U.S.-born workers in computer-related fields in recent years. Our analysis focuses on the impact of the H-1B visa lotteries that occurred in 2007 and 2008. Although this is just one snapshot of the full impact that our broken immigration system has on growth in the tech sector, it represents a major issue for tech firms, and one of particular concern to companies now. This year, tech firms once again had to go through an H-1B visa lottery to see which applicants would be eligible for visas, a process that eliminated close to 88,000 visa applications nationwide from consideration.[14]

In the following sections, our results are presented as both high and low estimates. This reflects different specifications, or statistical approaches, we used to assess the impact of the H-1B lotteries and the steps we took to make sure that various factors in the data were accounted for in our analysis.  In total, we use four specifications to assess the possible impact that unsuccessful H-1B applications for information technology workers had on the job and wage growth of U.S.-born computer workers from 2005 to 2010. One specification shows the results for the average metropolitan area in the country, weighting each city—no matter how big or small— equally in the final result. The next two specifications take the extra step of weighting each metropolitan

area based on one of two factors: Either the share of the country's total H-1B applications that originated from that place or how dependent employers in that area are on using foreign-born computer workers to staff their firms. This weighted approach helps us check that smaller cities whose data has a larger sampling error aren't unnecessarily swaying our results. The last specification eliminates the city of Trenton, New Jersey from the figures altogether. Trenton's large figures skew the data, so we removed it to be more conservative in our estimates. (More details on our calculations and the coefficients they produced can be found in the Methodology Appendix.)

Our calculations strongly refute the argument that H-1B workers in the IT industry take jobs away from their U.S.-born competitors. In every one of our models, cities that had larger H-1B shocks experienced slower growth in the number of jobs available for U.S.-born computer workers—both high- and low-skilled—in the years that followed. Specifically, we found that every time a city experienced a 1 percent shock in the available supply of computer workers (as a result of the H-1B visa lotteries in 2007 and 2008)[15], the growth in the number of jobs available for non-college educated, U.S.-born workers slowed as much as 7.1 percent between the 2005-2006 and 2009-2010 time periods. For equivalent U.S.-born college-educated workers, it slowed by as much as 1.3 percent during that time. We also found that employers who were denied H-1B visas were not able to respond by hiring high-skilled, U.S.-born workers in their place.

That impact of the 2007 and 2008 H-1B lotteries, of course, becomes clearer when translated into the number of jobs that were lost from our economy as a direct result of our country's broken high-skilled immigration system. From 2005-2006 to 2009-2010, America's metropolitan areas added roughly 110,000 jobs for U.S.-born workers in computer-related fields. We found that

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14  Roy Mauer, Society for Human Resource Management, "51% of FY 2015 H-1B Petitions Rejected in USCIS Lottery" (April 14, 2014). Accessed May 15, 2014. Available here: http://www.shrm.org/hrdisciplines/safetysecurity/articles/pages/2015-h1b-petitions-rejected-uscis-lottery.aspx.

15  The term "H-1B shock" is used frequently throughout the report. This term refers to how the number denied H-1B visas in computer-related fields compares to the total number of jobs in the city in those fields in 2005 and 2006. A metropolitan area that experienced an H-1B supply shock of one percent would be a city where the average number of H-1B denials per year in 2007 and 2008 was equivalent to roughly 1 percent of the city's total workforce in computer-related fields during the 2005-2006 periods. In other words, simply approving the H-1B visa applications requested in 2007-2008 would have grown the city's total employment in computer-related fields by 1 percent, before other factors—like the boost in native-born employment that would resulted—are even accounted for.

if the US had not faced so many H-1B denials in 2007 and 2008 that figure would have been at least 55 percent higher. Our low estimate predicts that by 2009-2010, the 2007 and 2008 H-1B visa lotteries had caused U.S. metropolitan areas to miss out on creating roughly 60,000 new jobs for U.S.-born IT workers. Our higher estimate, however, predicts that the H-1B lotteries cost city-based U.S.-born tech workers as many as 231,200 new jobs during that period—a figure more than three times higher than the actual number of new jobs created for those workers during that time frame. (See Table 3.) Our figures also indicate that the majority of the jobs

for U.S.-born workers described above would not have gone to the high-skilled computer workers, that companies say they have trouble recruiting but rather to the less-skilled, non-college educated workers who often support their work. More than four out of five jobs that would have been created for U.S.-born computer workers (using our high estimates) would have gone to U.S.-born computer workers without a college degree. That translates into almost 189,000 additional jobs that could have been created by 2009-2010—a figure that would have grown U.S.-born, less-skilled employment in the computer related fields by almost 28 percent over

## TABLE 3:

### How Much Faster The Tech Industry Could Have Grown by 2009-2010 Without H-1B Visa Rationing in 2007-2008

DATA FOR 236 METROPOLITAN AREAS

| | Actual Jobs for U.S.-Born Workers in Computer Fields | | |
| --- | --- | --- | --- |
| | College-Educated | Non-College Educated | Both |
| 2005-2006 | 993,453 | 659,216 | 1,674,922 |
| 2009-2010 | 1,082,218 | 702,624 | 1,784,842 |
| Jobs Created | 88,765 | 43,408 | 109,920 |

| | Additional Jobs that Would Have Existed in 2009-2010 Without 2007 and 2008 H-1B Visa Lottery Denials | | |
| --- | --- | --- | --- |
| | College-Educated | Non-College Educated | Both |
| Low Estimate | 25,365 | 34,704 | 60,069 |
| Percent Increase in Job Creation Over Actual Number of Jobs Created | 28.6% | 79.9% | 54.6% |
| High Estimate | 42,637 | 188,563 | 231,200 |
| Percent Increase in Job Creation Over Actual Number of Jobs Created | 48.0% | 434.4% | 210.3% |

actual 2010 levels.

It's worth noting that those less-skilled jobs would have gone to a population that was being particularly hard hit by the recession that was occurring during the period we examine here. From the start of the recession to mid-2009, the unemployment rate for the U.S. population overall climbed by 4.5 percent.  However, for Americans with less than a high school diploma, a crucial subset of the less-skilled population considered here, the unemployment rate jumped 7.8 percent during that period—reaching 15.8 percent.[16] In the recovery since then, less-skilled workers overall have only continued to lose ground to Americans with at least some college education: By mid-2013, the number of Americans with no college education holding jobs remained smaller than the number of people with that profile who were working when the recession began in 2007. The opposite was true for workers with bachelor's degrees.[17]

It is also likely that the jobs that would have been created if the U.S. had not denied so many visas in the H-1B lotteries would have been attractive, well-compensated ones. The Bureau of Labor Statistics recognizes 10 professions in the Computer and Information Technology Fields.  Of those, all 10 boasted a median pay that was higher than the average paid to all workers in 2012. Computer Information Research Scientists had a median wage of $102,190 in 2012, while that figure for software developers and computer network architects topped $90,000.  Web developers and computer support specialists—professions that are open to individuals with associate's degrees—had median pay of $62,500 and $48,900, respectively.[18] To put those figures in context, the median annual wage for all full-time and salaried workers aged 16 and above was $39,936 in 2012, according to the Current Population Survey.[19]

Harvinder Singh, the CEO of Bestica, an IT staffing firm in San Antonio, Texas, knows very well how struggles applying for and receiving H-1B visas can result in smaller tech companies and fewer jobs for U.S.-born workers. Since his company was founded in 2005, Singh's firm has had mixed success sponsoring H-1B visas and helping H-1B visa holders already in the country transfer to his firm. Such struggles—and the limits on the number of visas available—have led him to stop using the program altogether. "I think that you can try to change a system, or you can try to deal with the system you have," Singh says, "I'm at a stage where I'm just trying to learn to live with our broken visa system."

Not having access to H-1B workers, however, slows down what Bestica is able to achieve. The firm, which focuses on making websites and mobile applications more user friendly, currently does work for many major Fortune 500 firms, including Samsung, Bank of America, and Microsoft. But Bestica also turns down a lot of work too, largely because it doesn't have enough high-skilled workers to take on many proposed projects. "If the immigration policy for qualified STEM workers is eventually improved," Singh says, "I really think it's not only going to help grow tech businesses like mine, but our economy as a whole." Singh says if the H-1B system had not presented him with so many headaches over the years, he estimates his firm could be employing twice as many people as it does today. That would be 25 additional tech jobs in the city of San Antonio— and Singh estimates a large share of them would be for U.S.-born workers playing roles in operations, sales, or support for his expanded team.

The figures above detailing the number of tech jobs "lost" from our economy as a direct result of the 2007 and 2008 visa lotteries is in some ways an underestimate. As mentioned above, the coefficients our models produced indicate that employers were not able to fill the roughly 178,000 positions set aside for H-1B employees with U.S.-born workers instead. Instead, the vast majority of those jobs were done away with altogether or left unfilled, meaning they too can be counted as jobs "lost" as a direct result of the large number of H-1B visa denials in 2007 and 2008. Altogether, that means that U.S. employers in computer-related fields would have had as many as 409,000 additional jobs of all backgrounds (US-born and foreign-born) by 2009-2010 if not for the H-1B visa lottery—a substantially larger employment base that would have expanded the U.S. income tax revenue and potentially contributed to innovation and patenting levels at America's tech firms.

16  James Sherk, The Heritage Foundation, Postpone the Minimum Wage Increase until Low-Skilled Unemployment Falls, Web Mem"o (July 23, 2009).  Accessed May 12, 2014. Available here: http://www.heritage.org/research/reports/2009/07/postpone-minimum-wage-increase-until-low-skilled-unemployment-falls.

17  Catherine Rampell, The New York Times, "College Graduates Fare Well in Job Market, Even Through Recession" (May 3, 2013). Available here: http://www.nytimes.com/2013/05/04/business/college-graduates-fare-well-in-jobs-market-even-through-recession.html.

18  Bureau of Labor Statistics, "Occupational Outlook Handbook: Computer and Information Technology Occupations" (2014). Accessed May 22, 2014. Available here: http://www.bls.gov/ooh/computer-and-information-technology/home.htm

19  This figure is calculated based on the annual weekly wages paid to such workers, multiplied by 52 weeks per year.  For data on the median weekly wage, see here: http://www.bls.gov/cps/tables.htm#annual.

# Part IV: The Wage Effect

The large number of H-1B visa denials in 2007 and 2008 did not just impact the number of jobs available to U.S.-born workers in computer related fields. It also impacted the wages that U.S.-born IT workers who had jobs were paid for their work.  The idea that H-1B workers actually raise the wages of similarly skilled U.S.-born workers is not new. A recent study we conducted found that from 1990, when the H-1B program was created, to 2010, a surge in the number of H-1B workers in STEM fields significantly increased the wages of U.S.-born, college-educated workers in a given city over the course of the following decade.[20] The Brookings Institution has also found that from 2009 to 2011 wages for U.S.-born, high-skilled workers grew particularly rapidly in the STEM occupations that submitted the largest number of H-1B requests.[21]

In this section, we examine the relationship between an adequate supply of H-1B workers and native-born wage growth, using a much more credible method to establish causation than previous work. We do this by showing how the large number of randomized visa denials in the H-1B visa lotteries of 2007 and 2008 depressed the ability of employers in the computer-related fields to expand and grow the wages paid to U.S.-born workers in cities across the country in the period from 2005–2006 to 2009-2010. The population potentially impacted by this slowdown in wage growth was sizable. Our analysis looks at the wages that would have been paid to U.S.-born computer workers located in 236 metropolitan areas across the country in 2009.  That year, more than 1.8 million U.S.-born individuals were working in computer-related positions in those metropolitan areas—including more than 1.1 million college-educated workers and almost 720,000 people without a bachelor's degree.

Our work finds that the college-educated portion of that population experienced a notable slowdown in their wage growth as a direct result of the visa lottery denials in 2007 and 2008. The models we produced, which are available in the methodology appendix, demonstrated that for every 1 percentage point shock in the supply of computer workers in a given metropolitan area, wage growth for U.S.-born, college-educated computer workers there slowed by between 0.26 to 0.79 percentage points in the two years that followed. The shock in the supply of high-skilled workers that actually occurred due to the lotteries, however, was far greater than 1 percent—totaling 4.1 percent for the average metropolitan area in our sample. In real terms, that means that the H-1B visa denials in 2007 and 2008 actually slowed the wage growth of U.S.-born computer workers by as much as 3.2 percent between 2005–2006 and 2009–2010.

We can better understand the full impact of the H-1B lotteries on the wage growth of American computer workers by translating the above figures into actual dollars missing from our economy in 2009. [22]If the H-1B lotteries of 2007 and 2008 had not slowed down tech industry expansion, the average U.S.-born, college-educated computer worker would have earned between $861 and $2,672 more per year in the 2009-2010 period. In the aggregate, that translates into as much as $2.96 billion in wages lost from our economy in 2010 due to the earlier H-1B denials. (See Table 4.) These aggregate figures provide an indication of the magnitude of the impact to our economy of a broken H-1B visa system. They also dispel the notion that foreign-born H-1B workers are harming native-born workers in the industries where they work.

It is also worth noting that the actual wages of U.S.-born computer workers grew quite slowly during the period examined in our study. From 2007 to 2010, the wages of U.S.-born, college-educated workers actually fell slightly, shrinking by 0.03 percent. Our figures indicate that without the H-1B visa denials, wages for U.S.-born, college-educated computer workers would have grown faster during the entire 2005–2006 to 2009-2010 time period. Instead of growing 1.7 percent during that time, the presence of the 178,000 rejected H-1B workers would have raised wages by as much as 4.9 percent, meaning higher pay for more than a million American families. (See Figure 2.)

Guy Horrocks, the founder and CEO of Carnival Mobile, a firm that helps Fortune 500 brands manage their mobile applications, , says that the country's broken H-1B visa system has prevented his firm from growing and expanding his payroll as rapidly as he would like.

20  Giovanni Peri,  Kevin Shih and Chad Sparber, (2014). "Foreign STEM Workers and Native Wages and Employment in U.S. Cities," NBER Working Papers 20093, National Bureau of Economic Research, Inc.

21  Jonathan Rothwell and Neil G. Ruiz, Brookings, "H-1B Visas and the STEM Shortage" (May 10, 2013). Accessed May 22, 2014. Available here: http://www.brookings.edu/research/papers/2013/05/10-h1b-visas-stem-rothwell-ruiz

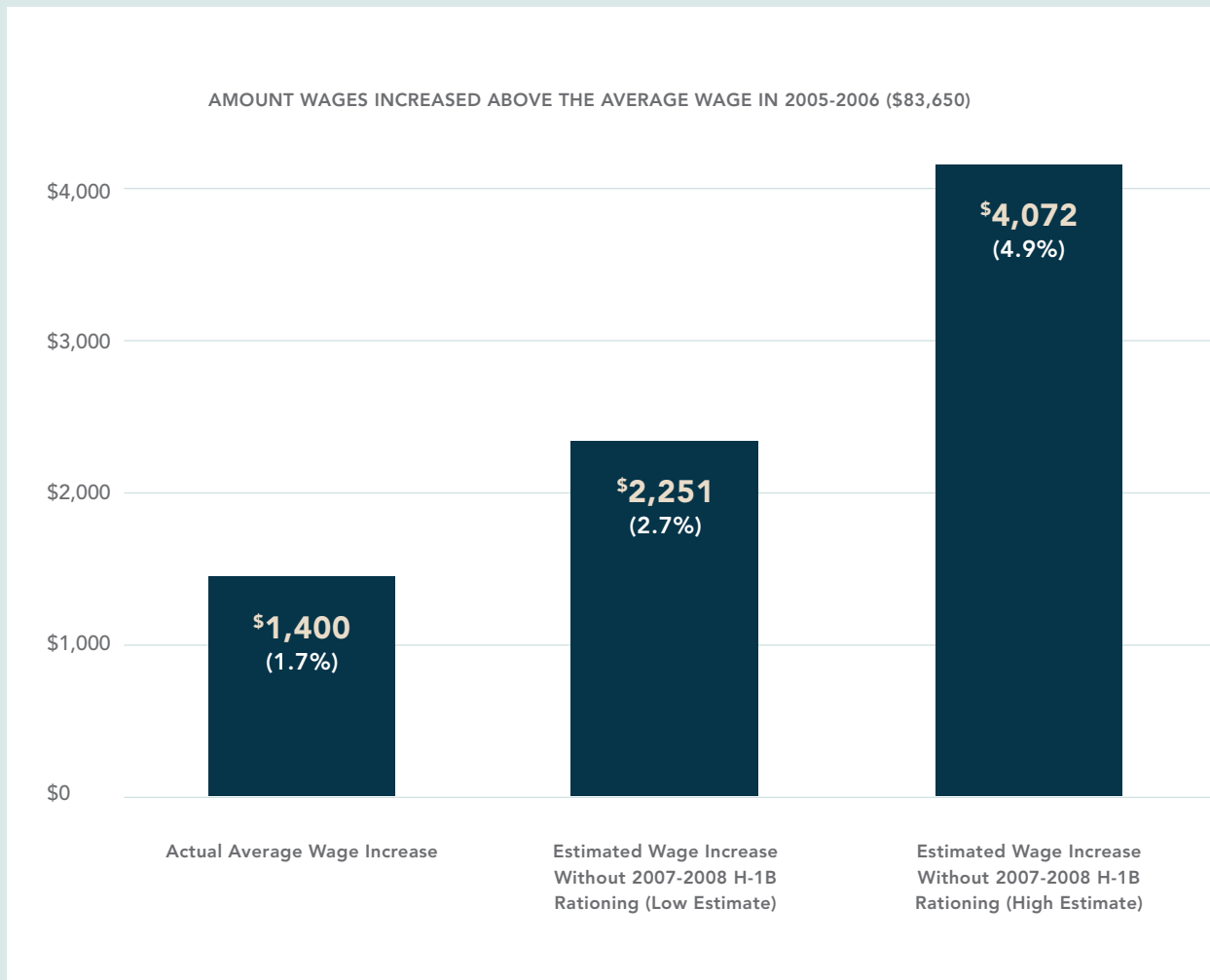22  All figures presented in this section are in 2010 constant dollars.

## TABLE 4:

**Additional Yearly Wages that Would have Been Earned by U.S.-Born, College-Educated Computer Workers in 2009-2010 without the H-1B Visa Lotteries of 2007 and 2008**

| | Additional Annual Wages Per Worker | Additional Total Aggregate Wage |
|---|---|---|
| Low Estimate | $851 | $944,729,991 |
| High Esimate | $2,672 | $2,966,296,752 |

## FIGURE 2:

**Actual and Expected Wage Growth for U.S.-Born, College-Educated, Computer Workers in 236 Metropolitan Areas, 2005-2006 to 2009-2010**



AMOUNT WAGES INCREASED ABOVE THE AVERAGE WAGE IN 2005-2006 ($83,650)

- Actual Average Wage Increase: $1,400 (1.7%)
- Estimated Wage Increase Without 2007-2008 H-1B Rationing (Low Estimate): $2,251 (2.7%)
- Estimated Wage Increase Without 2007-2008 H-1B Rationing (High Estimate): $4,072 (4.9%)

Late last year,  Carnival raised $2.4 million—a huge milestone for a relatively young firm. For the last 18 months, however, a New Zealand native with legal and computer science training that Horrocks wants to hire to run all his firm's legal, HR, and business affairs has been living in New York on a tourist visa that prevents her from working. Horrocks's firm tried to sponsor her for an H–1B visa earlier this year, only to learn that her application didn't make it through this year's H–1B visa lottery. "It's been incredibly frustrating," Horrocks says, "Whether or not someone gets to come to this country should be based on the jobs that can be created—or the outcomes the person can produce for a firm—not the results of a random lottery."

The situation is also slowing down what Carnival is able to achieve. While the position remains open, Horrocks has had to do much of the hiring and HR work for the company himself—a slow process that takes away from his time spent working on the core business of the firm. He estimates he's spent about 100 hours on this work so far. "We are not hiring as quickly as we could," Horrocks says, "And it's incredibly distracting to me as the CEO." Horrocks, who had his own visa headaches when trying to move to America, estimates that if visa issues had not been such a problem for his firm, the company's New York office would be twice as big today as it is now. He says it's possible that revenues and profits could be higher as well.

When looking at wage data for U.S.-born workers in computer related fields without a bachelor's degree, our models found that the 2007 and 2008 denials of H–1B visas had only a very mild impact on the wage growth of those workers in subsequent years. Our figures showed that for every 1 percent shock in the supply of H–1B workers in a given city in 2007 and 2008, the wage growth of U.S.-born, non–college–educated workers in computer fields there was changed by a statistically

insignificant amount. As a result, we chose to leave such workers out of our analysis on aggregate wage impact.

It's worth noting that the data detailed in this section only considers the added wages that would have gone to the more than 1.8 million U.S.-born workers who actually had jobs in computer-related fields 2009. As discussed in the previous section, however, our country would have had as many as 231,224 additional jobs for U.S.-born computer workers in 2009 -2010 if not for the H–1B visa lotteries two years prior. Because many of those jobs would have likely been highly compensated— and many American workers eligible for them may have been underemployed or unemployed in 2009—it's likely that these additional positions would have also added substantially to America's total income base, boosting U.S. consumer spending and tax revenues while the country struggled to fully recover from the recession.
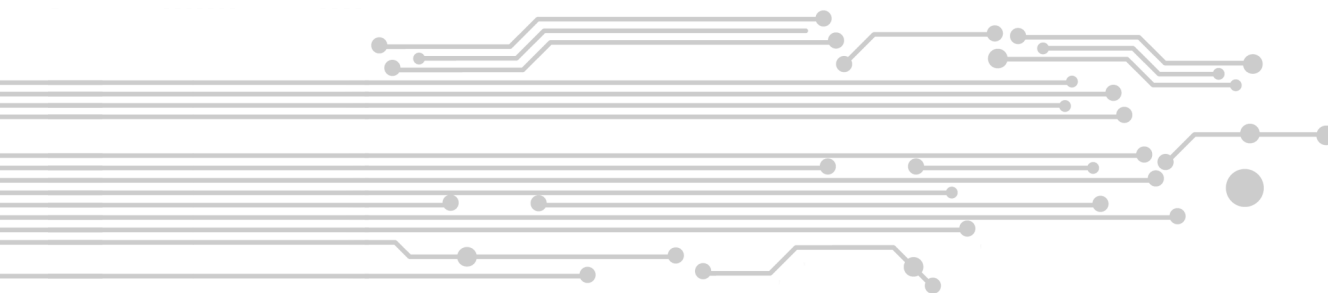
# Part V: The Impact of the H-1B Program on Specific U.S. Cities

Our figures show that several major U.S. metropolitan areas could have had substantially more jobs for workers in computer-related industries in 2009, if not for the drag that the H-1B visa lotteries put on tech industry expansion in the years that followed. These cities include areas in all regions of the country and areas both strongly identified and less identified as epicenters of technology and innovation. In Table 5 we show the 25 U.S. metropolitan areas that missed out on creating the most jobs due to the 2007 and 2008 H-1B visa lotteries.[23] The chart shows the number of jobs that would have existed in each place by 2009-2010, as well as the additional aggregate annual income that would have been paid to U.S.-born tech workers there. That additional income can be meaningful for cities, boosting tax revenue and potentially the amount of money spent by workers at local service businesses.

As the chart demonstrates, the Washington, DC metropolitan area lost out on the most jobs as a direct result of H-1B visa denials in 2007 and 2008.  That area, which includes parts of Northern Virginia and Southern Maryland, lost out on as many as 30,222 jobs for U.S.-born computer workers by 2009-2010 as a direct result of the visa lotteries, including as many as 22,922 jobs for U.S.-born computer workers without a bachelor's degree. By 2009-2010, the roughly 28,000 H-1B visa denials employers in the area had experienced in the 2007 and 2008 H-1B visa lotteries was also shaving between $170 million and $520 million off the total wages earned by U.S.-born computer workers in the

area each year.

Other major U.S. cities were impacted on a similar scale. In the Atlanta metropolitan area, an area that had an unemployment rate higher than the national average in December 2010,[24] the  roughly 8,700 H-1B visa applications  that were eliminated in 2007 and 2008 lotteries kept local employers from creating as many as 11,052 computer-related jobs for U.S.-born workers by the 2009-2010 period. In the Dallas, Texas metropolitan area, the 2007 and 2008 H-1B visa lotteries cost the city between 2,636 and 10,638 jobs, and as much as $112 million in computer-industry wages. Chicago, which struggled with unemployment rates more than one whole percentage point higher than the national average in early 2010,[25] could have had as many as 16,642 additional computer related jobs by 2009-2010 if not for our country's broken H-1B visa system.

One particularly interesting city impacted by recent H-1B trends was Detroit. After being the center of the American automobile industry for decades, the area's economy has struggled in more recent years to adapt to America's innovative, knowledge-driven economy.

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23  This list includes the top 20 cities based on our high estimate of the number of jobs lost between 2005-2006 and 2009-2010.

24  The non-seasonally adjusted unemployment rate for the Atlanta metropolitan area was 10.0 percent in December 2010, compared to a rate of 9.1 percent for the country as a whole. Metropolitan area data is from the Local Area Unemployment Statistics database on the Bureau of Labor Statistics Website. Accessed May 14, 2014. Available here: http://www.bls.gov/lau/data.htm.  National statistics are also from the Bureau of Labor Statistics, available here: http://data.bls.gov/timeseries/LNU04000000.

25  Chicago's unemployment rate was 11.9 percent in January 2010, compared to 10.6 percent of the country overall.  See sourcing in note 23.

## TABLE 5:

**Estimated Jobs and Wages U.S.-Born Computer Workers Had Lost by 2009-2010 Due to H-1B Visa Denials in the 2007-2008 Period**

TOP 25 METROPOLITAN AREAS BY NUMBER OF POTENTIAL JOBS LOST

| Metropolitan area | Yearly Computer Employment 2005-2006 | Average Number of H1B Visas Denied per Year 2007-2008 | Size of H-1B Normalized Visa Shock | Jobs Lost for U.S.-Born, College-Educated Workers | | Jobs Lost for U.S.-Born Workers Without a Bachelor's Degree | |
|---|---|---|---|---|---|---|---|
| | | | | Low Estimate | High Estimate | Low Estimate | High Estimate |
| Washington, DC/MD/VA | 132,901 | 14,060 | 10.6% | 4,157 | 7,300 | 4,219 | 22,922 |
| New York City-Northeastern NJ | 168,330 | 17,104 | 10.2% | 3,790 | 6,655 | 3,939 | 21,400 |
| Chicago, IL | 89,503 | 7,410 | 8.3% | 2,068 | 3,631 | 2,395 | 13,011 |
| Detroit, MI | 40,366 | 5,386 | 13.3% | 1,278 | 2,244 | 2,347 | 12,750 |
| Atlanta, GA | 65,672 | 4,346 | 6.6% | 1,274 | 2,238 | 1,622 | 8,814 |
| Dallas-Fort Worth, TX | 80,640 | 3,820 | 4.7% | 991 | 1,740 | 1,647 | 8,948 |
| Philadelphia, PA/NJ | 57,188 | 2,216 | 3.9% | 635 | 1,115 | 873 | 4,744 |
| Los Angeles-Long Beach, CA | 89,645 | 2,401 | 2.7% | 483 | 849 | 763 | 4,146 |
| Trenton, NJ | 6,148 | 2,280 | 37.1% | 456 | 801 | 657 | 3,567 |
| San Francisco-Oakland, CA | 70,102 | 2,704 | 3.9% | 591 | 1,038 | 585 | 3,181 |
| Houston-Brazoria, TX | 40,046 | 1,589 | 4.0% | 366 | 643 | 598 | 3,251 |
| San Jose, CA | 54,001 | 4,641 | 8.6% | 748 | 1,314 | 437 | 2,372 |
| Boston, MA-NH | 63,084 | 1,903 | 3.0% | 585 | 1,027 | 396 | 2,149 |
| Wilmington, DE/NJ/MD | 7,052 | 1,345 | 19.1% | 289 | 507 | 471 | 2,560 |
| Raleigh-Durham, NC | 27,746 | 1,112 | 4.0% | 418 | 735 | 335 | 1,822 |
| Columbus, OH | 21,632 | 748 | 3.5% | 212 | 373 | 354 | 1,925 |
| Pittsburgh, PA | 16,858 | 830 | 4.9% | 294 | 517 | 312 | 1,694 |
| Seattle-Everett, WA | 58,933 | 1,013 | 1.7% | 276 | 484 | 313 | 1,699 |
| Kansas City, MO-KS | 25,849 | 658 | 2.5% | 222 | 390 | 284 | 1,542 |
| Phoenix, AZ | 32,800 | 570 | 1.7% | 143 | 251 | 307 | 1,670 |
| Tampa, FL | 23,122 | 548 | 2.4% | 132 | 232 | 307 | 1,669 |
| Baltimore, MD | 38,386 | 557 | 1.5% | 177 | 310 | 232 | 1,261 |
| Nashville, TN | 10,508 | 373 | 3.6% | 120 | 210 | 193 | 1,049 |
| San Diego, CA | 32,258 | 491 | 1.5% | 137 | 240 | 180 | 977 |
| Jacksonville, FL | 10,214 | 306 | 3.0% | 65 | 115 | 197 | 1,070 |

## TABLE 5:

**Estimated Jobs and Wages U.S.-Born Computer Workers Had Lost by 2009-2010 Due to H-1B Visa Denials in the 2007-2008 Period**

TOP 25 METROPOLITAN AREAS BY NUMBER OF POTENTIAL JOBS LOST

| Metropolitan area | Total jobs lost for All U.S.-Born Computer Workers | | Average Annual Wage for College Educated, U.S.-Born Workers, 2005-2006 | Average Annual Wage for U.S.-Born Workers Without a College Degree in 2005-2006 | Native College-Educated Aggregate Yearly Wage Lost, 2009-2010 (in Millions) | |
|---|---|---|---|---|---|---|
| | Low Estimate | High Estimate | | | Low Estimate | High Estimate |
| Washington, DC/MD/VA | 8,376 | 30,222 | $95,505 | $84,122 | $169.877 | $519.471 |
| New York City-Northeastern NJ | 7,729 | 28,055 | $94,899 | $76,668 | $153.878 | $470.540 |
| Chicago, IL | 4,463 | 16,642 | $86,313 | $70,385 | $76.373 | $233.509 |
| Detroit, MI | 3,625 | 14,994 | $81,262 | $63,987 | $44.441 | $135.895 |
| Atlanta, GA | 2,896 | 11,052 | $80,726 | $67,233 | $43.997 | $134.608 |
| Dallas-Fort Worth, TX | 2,638 | 10,688 | $86,874 | $66,826 | $36.828 | $112.599 |
| Philadelphia, PA/NJ | 1,508 | 5,859 | $83,923 | $67,431 | $22.800 | $69.731 |
| Los Angeles-Long Beach, CA | 1,246 | 4,995 | $89,738 | $74,131 | $18.562 | $56.764 |
| Trenton, NJ | 1,113 | 4,368 | $95,292 | $81,540 | $18.588 | $56.845 |
| San Francisco-Oakland, CA | 1,176 | 4,219 | $102,316 | $78,060 | $25.876 | $79.152 |
| Houston-Brazoria, TX | 964 | 3,894 | $85,062 | $66,836 | $13.320 | $40.725 |
| San Jose, CA | 1,185 | 3,686 | $125,494 | $90,373 | $40.155 | $122.819 |
| Boston, MA-NH | 981 | 3,176 | $95,298 | $73,837 | $23.846 | $72.919 |
| Wilmington, DE/NJ/MD | 760 | 3,067 | $82,920 | $65,949 | $10.238 | $31.310 |
| Raleigh-Durham, NC | 753 | 2,557 | $86,010 | $70,400 | $15.401 | $47.087 |
| Columbus, OH | 566 | 2,298 | $72,539 | $62,941 | $6.583 | $20.134 |
| Pittsburgh, PA | 606 | 2,211 | $69,281 | $59,114 | $8.730 | $26.687 |
| Seattle-Everett, WA | 589 | 2,183 | $89,047 | $72,482 | $10.512 | $32.147 |
| Kansas City, MO-KS | 506 | 1,932 | $72,195 | $61,907 | $6.852 | $20.961 |
| Phoenix, AZ | 450 | 1,921 | $77,840 | $66,459 | $4.760 | $14.552 |
| Tampa, FL | 439 | 1,901 | $71,621 | $60,776 | $4.041 | $12.352 |
| Baltimore, MD | 409 | 1,571 | $87,047 | $69,807 | $6.577 | $20.113 |
| Nashville, TN | 313 | 1,259 | $75,153 | $58,139 | $3.845 | $11.763 |
| San Diego, CA | 317 | 1,217 | $89,569 | $67,791 | $5.247 | $16.040 |
| Jacksonville, FL | 262 | 1,185 | $75,279 | $62,878 | $2.106 | $6.436 |

In January 2010, more than one in seven adults over the age of 16 in the Detroit metropolitan area were unemployed.  The 700,000-person city, once the fourth largest in the country, had also seen its population shrink by more than 1 million people since its peak in 1950.[26] Heavy financial troubles led the city government to file for Chapter 9 bankruptcy in 2013.[27]

In the midst of all these developments, computer industry employers in the Detroit metropolitan area were particularly hard hit by the H–1B lotteries. Our figures show that in 2007 and 2008, employers in Detroit trying to expand their operations saw an average of more than 5,300 H–1B applications eliminated in the lottery each year. Simply approving those visas—before even considering any other boost to employment that would have resulted—would have expanded the number of technology jobs in the city by almost 27 percent above 2005–2006 levels. It also would have created numerous, potentially well-compensated positions in Detroit's economy for U.S.-born workers as well. We estimate that approving the H–1B applications would have generated as many as 14,999 jobs for U.S.-born workers in computer-related fields. By 2009–2010, the annual wages of already existent U.S.-born, college-educated computer workers would have been between $44 million and $135 million higher per year as well.

Gov. Rick Snyder of Michigan points to the difficultly foreign students have remaining in America after graduation as a major piece of the H–1B visa problem that has hurt his state. "While foreign talent can readily obtain a student visa, remaining a member of the Michigan community is made difficult for those desiring to do so under current immigration laws," he says. "The difficulty also significantly disrupts businesses that rely on these skilled and talented individuals." Discussing the current H–1B visa caps, he adds, "These caps are arbitrary and fail to recognize the harm done to local economies when states are forced to send away talent they have spent years developing."

The H–1B visa lotteries of 2007 and 2008 also resulted in a major missed opportunity for several smaller metropolitan areas. As discussed earlier in the report, one key way that we assessed the impact of H–1B denials city-by-city was by looking at how the number of visas eliminated in the lottery for computer-related

workers compared to the levels of employment in those fields in each city in 2005-2006, a measure we refer to as an "H-1B shock."  Of the 236 metropolitan areas we considered in the report, two of the 15 areas that experienced the largest H-1B shocks were in the state of New Hampshire—Manchester and Nashua. Those two metropolitan areas could have created as many as 872 additional jobs for U.S.-born tech workers if they hadn't suffered so many denials in the 2007 and 2008 periods. Other small metropolitan areas like Davenport, Iowa, Portland, Maine, and Akron, Ohio lost out on creating hundreds of computer jobs for U.S. born workers according to both our high and low estimates.

Even areas with rapidly growing tech sectors saw their growth slowed by recent H–1B trends. In the last decade, Jacksonville, Florida has experienced rapid growth in its tech sector. In 2013, Forbes ranked Jacksonville the second fastest growing U.S. city adding computer, professional, and technological services jobs, second only to Austin, Texas.[28] Our figures show, however, that the hundreds of H–1B visa applications from the city's employers eliminated in the 2007 and 2008 visa lotteries cost U.S.-born computer workers in the city as many as 1,185 jobs by 2009–2010 and existing college-educated IT workers between roughly $2 and $6.5 million in annual aggregate wages.
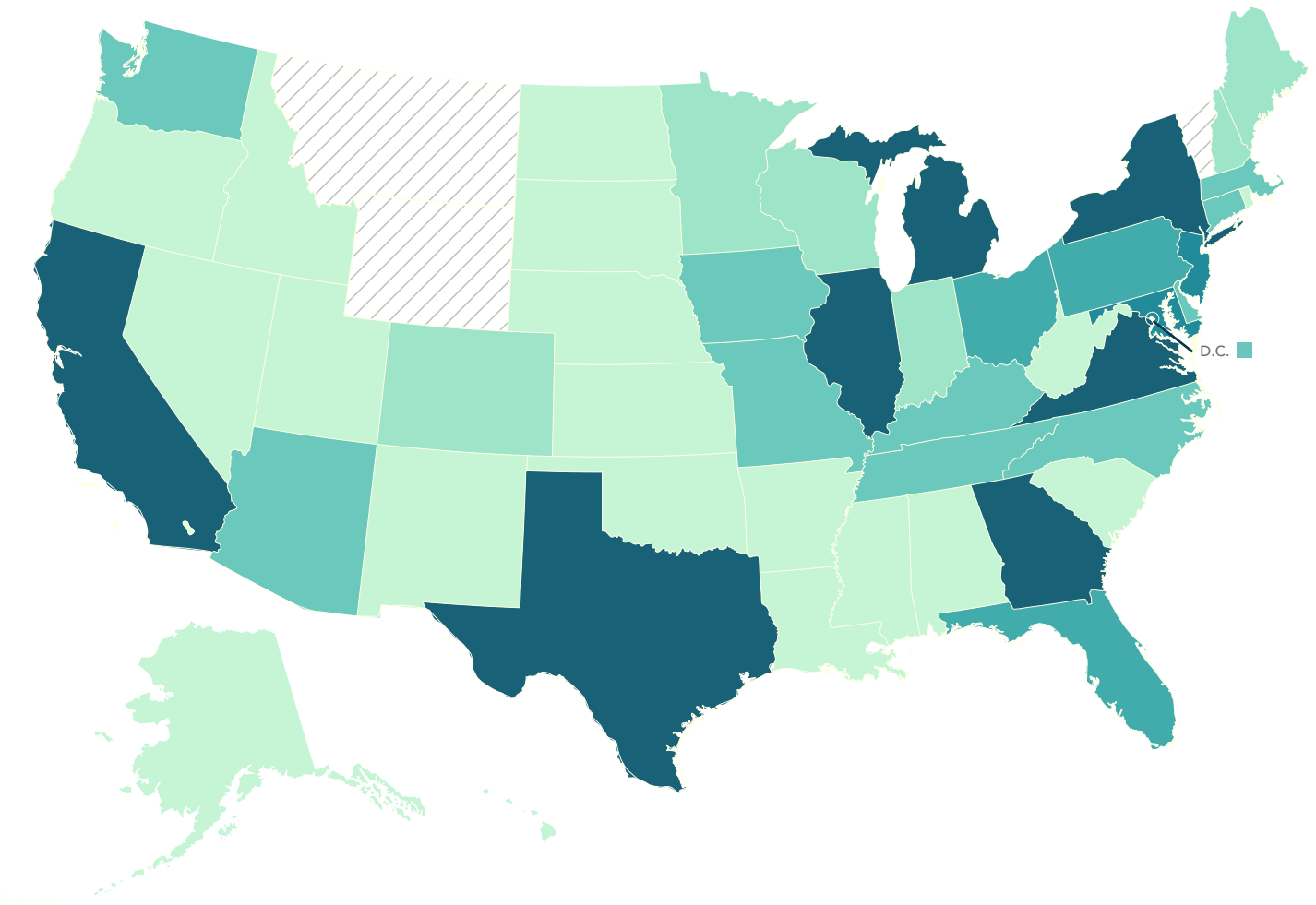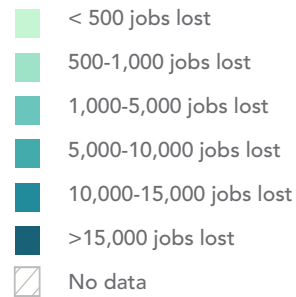
26  Kofi Moyler, Detroit Free Press, "Detroit's Population from 1840 to 2012 Shows High Points, Decades of Decline," (July 23, 2013). Available here: http://www.freep.com/interactive/article/20130723/NEWS01/130721003/detroit-city-population.

27  Ibid.

28  Joel Kotkin, Forbes, "The Cities Winning the Battle for the Biggest Growth Sector in the U.S." (Feb. 2, 2013). Accessed May 14, 2014. Available here:  http://www.forbes.com/sites/joelkotkin/2013/02/07/the-cities-winning-the-battle-for-the-biggest-growth-sector-in-the-u-s/

## FIGURE 3:

**Number of Jobs for U.S.-Born Workers "Lost" from States Due to H-1B Visa Lotteries in 2007 and 2008, according to High Estimate**

COMPUTER-RELATED OCCUPATIONS ONLY



Legend:
- < 500 jobs lost
- 500-1,000 jobs lost
- 1,000-5,000 jobs lost
- 5,000-10,000 jobs lost
- 10,000-15,000 jobs lost
- >15,000 jobs lost
- No data

The figures presented in this map are rough estimates of the impact of the H-1B visa lottery on individual states. The data our report looks at information for 236 metropolitan areas across the country, as recognized by the U.S. Census.  Twenty-one of those cities span more than one state, such as Kansas City, which is split between Missouri and Kansas, and the Allentown-Bethlehem-Easton area, which is split between Pennsylvania and New Jersey.  For this map we placed each of those metropolitan area's data in the state where the predominate city in the sample is located, or where the majority of the population lives.  The two exceptions are Washington, DC and the New York City metropolitan area.  Because of the large impact of the H-1B visa lottery on each of those areas, we split the number of jobs lost in those areas in a way that mirrored the percentage breakdown of the population there based on place of residence.  In other words because 47 percent of Washington, DC's metropolitan area is located in Virginia, we estimate that 47 percent of the job "losses" for that metropolitan area occurred in Virginia as well. For a full list of the cities spanning more than one state, see the note in the appendix.
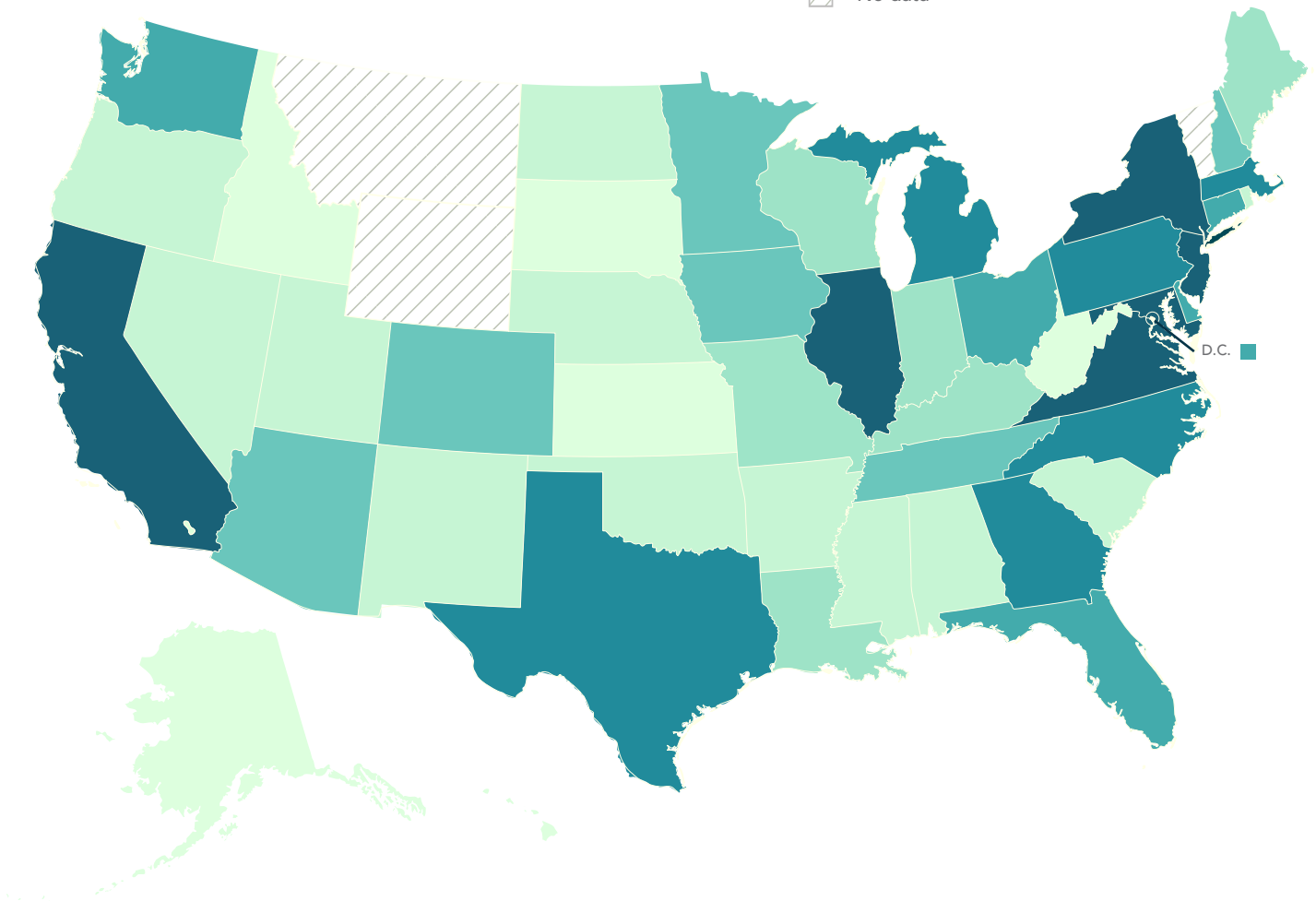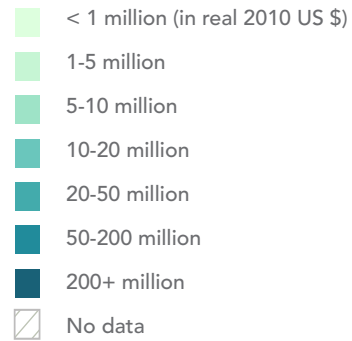
The sources for population data breakdowns for Washington, DC and New York City are as follows:
George Mason University Center for Regional Analysis, "Update from the U.S. Census: Population Growth in the Washington, DC Metropolitan Area" (April 2014). Accessed May 19, 2014. Available here: http://cra.gmu.edu/pdfs/studies_reports_presentations/Population_2013_Apr14.pdf.

Baruch College, "Metropolitan Statistical Area (MSA) Population New York-Northern NJ-Long Island- Pennsylvania" [Website]. Accessed May 19, 2014. Available here: http://www.baruch.cuny.edu/nycdata/population-geography/population.htm.

# FIGURE 4:

**Amount of Aggregate Wages Lost to U.S.-Born Computer Workers in 2009-2010 Due to the 2007 and 2008 H-1B Visa Lotteries, according to High Estimate**
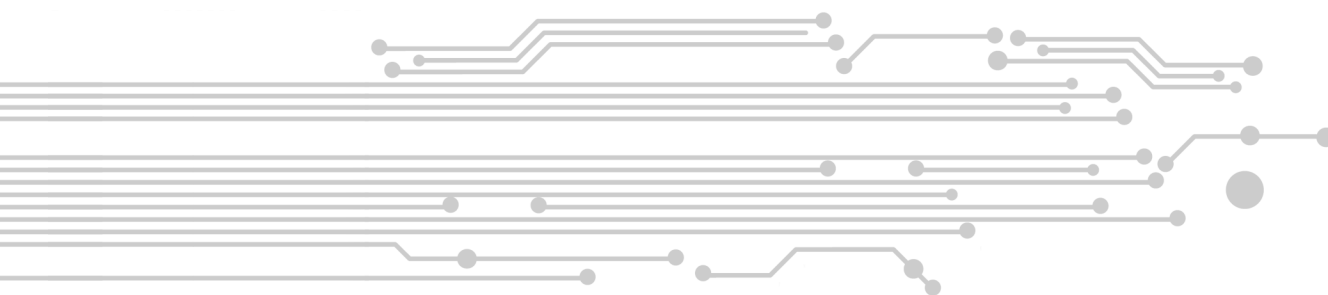
COMPUTER-RELATED OCCUPATIONS ONLY

- < 1 million (in real 2010 US $)
- 1-5 million
- 5-10 million
- 10-20 million
- 20-50 million
- 50-200 million
- 200+ million
- No data



The figures presented in this map are rough estimates of the impact of the H-1B visa lottery on individual states. The data our report looks at information for 236 metropolitan areas across the country, as recognized by the U.S. Census.  Twenty-one of those cities span more than one state, such as Kansas City, which is split between Missouri and Kansas, and the Allentown-Bethlehem-Easton area, which is split between Pennsylvania and New Jersey.  For this map we placed each of those metropolitan area's data in the state where the predominate city in the sample is located, or where the majority of the population lives.  The two exceptions are Washington, DC and the New York City metropolitan area.  Because of the large impact of the H-1B visa lottery on each of those areas, we split the number of jobs lost in those areas in a way that mirrored the percentage breakdown of the population there based on place of residence.  In other words because 47 percent of Washington, DC's metropolitan area is located in Virginia, we estimate that 47 percent of the job "losses" for that metropolitan area occurred in Virginia as well. For a full list of the cities spanning more than one state, see the note in the appendix.

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George Mason University Center for Regional Analysis, "Update from the U.S. Census: Population Growth in the Washington, DC Metropolitan Area" (April 2014). Accessed May 19, 2014. Available here: http://cra.gmu.edu/pdfs/studies_reports_presentations/Population_2013_Apr14.pdf.

Baruch College, "Metropolitan Statistical Area (MSA) Population New York-Northern NJ-Long Island- Pennsylvania" [Website]. Accessed May 19, 2014. Available here: http://www.baruch.cuny.edu/nycdata/population-geography/population.htm.

# Part VI: Conclusion

This report shows the degree to which our country's broken immigration system is hindering the ability of U.S. technology companies to expand and create attractive jobs for American workers in cities across the country. In this study, we examined the H–1B visa program, a part of our immigration system that is notoriously difficult for U.S. employers to navigate and chronically short of visas to meet the national demand. We found that the 178,000 visas for computer workers that were randomly denied to U.S. employers in the country's 236 metropolitan areas due to the 2007 and 2008 visa lotteries came at a huge cost to our economy. If those visas had been successful , U.S. cities would have boasted as many as 231,000 additional jobs for U.S.-born computer workers by 2009-2010, including as many as 188,000 jobs for less-skilled Americans—a group that was particularly impacted by the recent recession.

This report demonstrates why the country—and the tech sector in particular—is urgently in need of immigration reform. The hundreds of thousands of jobs—and millions more in wages—that could have been created for U.S.-born workers in the absence of the H-1B visa lotteries represent much more than just well-paid positions and professional opportunities for tens of thousands of American families. They represent the more vibrant tech sector that could exist if the U.S. was better able to compete on the world stage for global talent.  Past studies have found that more than 75 percent of the patents awarded to top universities have at least one foreign–born inventor.[29] Immigrants or their children also founded more than 40 percent of Fortune 500 firms.[30] Instead of pushing away the high–skilled immigrants that want to come to America and contribute, our country needs a visa system that continues our tradition of welcoming them.

The messages in this report are also very relevant to events now.  In April this year, USCIS received more applications towards the H-1B visa cap than it ever had before.[31] This once again prompted a visa lottery where more than half of applications, or 88,000 of them, were eliminated.[32] This report shows the very real impact that such a large number of H-1B visa denials can have on the ability of the U.S. tech sector to expand and add jobs in subsequent years. It's likely, however, that the dramatic number of lost jobs and wages described here underestimate the full economic consequences of our broken, high–skilled visa system.  Our work very purposefully focused on how the unavailability of H-1B visas to workers in computer–related positions impacted U.S.-born computer workers—the group most likely to compete with them. Past studies, however, have indicated that each high-tech worker in the country supports as many as five additional jobs in our economy, many in outside fields like accounting, medicine, and childcare.[33]  Taking those workers into account, the impact of the visa denials goes far beyond the conclusions of this study.

29  Partnership for a New American Economy, "Patent Pending: How Immigrants are Reinventing the American Economy" (June 2012). Available here: http://www.renewoureconomy.org/wp-content/uploads/2013/07/patent-pending.pdf.

30  Partnership for a New American Economy, "The 'New American' Fortune 500," (June 2011). Available here: http://www.renewoureconomy.org/wp-content/uploads/2013/07/new-american-fortune-500-june-2011.pdf.

31  See footnote 14.

32  Ibid.

33  Mark Muro, Brookings, "Multiplier Effects: Connecting the Innovation and Opportunity Agenda," (Aug. 23, 2012). Accessed May 15, 2014. Available here: http://www.brookings.edu/blogs/the-avenue/posts/2012/08/23-multiplier-effects-muro.

# Methodology Appendix

## BACKGROUND

The main innovation of this paper is that it uses genuinely random variation in the allocation of H–1B workers across labor markets in the U.S. resulting from the H–1B visa lotteries of 2007 and 2008. In those years, the number of new H–1B visa applications filed in the first month of acceptance far exceeded the 65,000 annual cap on the number of available visas the government can issue each year. The U.S. government responded by holding a visa lottery and randomly selecting 65,000 visa applications submitted by April 3rd in 2007 and April 7th in 2008 to move to the next round of processing. This produced a random negative shock in the supply of H–1B workers to different employers and to the cities in which they would have been located.

We merge two datasets to measure this supply shock across local labor markets. First, in order to hire an H–1B worker a firm must file a Labor Condition Application (LCA) stating the nature of the work. Publicly available LCA data records vacancies opened by employers for foreign workers, our measure of foreign labor demand. Second, foreign workers with LCA-approved job offers then apply for an H–1B visa using an I–129 form. United States Citizen and Immigration Services (USCIS) retains the I–129 records only for those individuals randomly selected for processing. Individual-level I–129 data, which we acquired through a Freedom of Information Act (FOIA) request, serves as a measure of capped labor supply.  We aggregate the supply and demand figures from these two datasets by metropolitan area and merge them accordingly. We select only the "computer-related occupations" because they represent two-thirds of applications and are thus especially subject to the quota and because they are those in which H–1B workers represent a larger share of total employment. For each city we calculate the randomly distributed negative H–1B supply shock, namely the number of non-satisfied applications among those that were subject to the quota.

After developing our H–1B supply shock data, we merge it with city-level labor market data derived from the American Community Survey in years 2006 (pre-lottery) through 2011 (three years after the second lottery). The resulting dataset allows us to conduct a regression to examine the causal relationship between skilled foreign labor flows and labor market outcomes. More specifically, our explanatory variable is the negative H–1B supply shock to computer-related occupations in a city relative to the pre-2007 computer-related employment in that city. This provides a measure of how the random lottery outcomes affected the availability of foreign-born workers in that local market. Our main outcome variables are the average computer-related native wages and employment in a city. As stated, we limit our attention to computer-related occupations because those jobs exhibit the largest incidence of H–1B workers in their total employment.

It is also worth noting that, by relying on a randomized sample, our work effectively controls for all of the economic factors that could have impacted metropolitan area computer employment between 2005–2006 and 2009–2010. In fact, all metropolitan areas were likely affected by the recession and other changes in demand during the period considered.  We identify only the differential consequences for metropolitan areas that randomly had a large number of H–1B applications eliminated in the 2007 and 2008 visa lotteries and those who had a far smaller number. As the lottery was random and not correlated with other economic events during the period, we can consider the impact of the H–1B lotteries on top of economic-labor market variations that may have occurred with or without the lotteries of 2007 and 2008.

## ADDITIONAL INFORMATION ON DATA SOURCES USED

As stated above, our data are from three separate sources. Lottery information comes from 2007 and 2008 LCA and I–129 data. Wage and employment information comes from the Census and American Community Surveys from 2000 through 2011.

We obtained LCA data from the U.S. Department of Labor. The forms include employer name, location (city and zip code), occupation, number of H–1B employees requested, the filing date, work start date, and work end date by year. This dataset helps to identify firm demand for foreign labor. It provides limited information on whether a hired employee would count toward the H–1B quota. Instead, we infer this from firm behavior in 2007 and 2008. Specifically, we assume that in those years, for-profit firms filing LCAs in March or April for September or October start dates are really hoping to hire a cap-dependent H–1B worker to start employment in October of the given year. This method will over-count cap-dependent demand since some firms meeting this criteria could include non-profit firms, firms hiring

workers with advanced degrees from U.S. universities, and/or firms that ultimately hire workers who renew their visas or come directly from another U.S. employer.

Our second database includes individual data on processed H-1B visa applications. This data comes from I-129 forms obtained from USCIS through a FOIA request. The forms include employer name, location (city and zip code), occupation, and several individual characteristics of the applicant. This dataset helps to identify the capped supply of foreign labor. It provides more information about whether a person would count toward the H-1B quota. First, we assume that prospective cap-dependent employees file I-129 petitions in April preceding the start of the fiscal year. We also assume that employees of colleges, universities, and other non-profit firms are cap-exempt. Since these employees will be dropped from the LCA count, we drop them from the I-129 count as well. Other cap-exempt H-1B workers, since they cannot be identified in the LCA data, remain in the merged dataset. This includes people applying for visa extensions, job changes, and citizens of countries effectively exempt from H-1B limits due to special bilateral trade agreements (Australians, Canadians, Chileans, Mexicans, and Singaporeans). These two datasets together provide us with a measure of unsatisfied demand for foreign labor. Specifically, we take the number of LCAs filed by for-profit institutions and subtract both the cap-dependent H-1Bs granted and the remaining cap-exempt H-1Bs granted to measure the number of denied visas by the lotteries of 2007 and 2008 (combined).

After aggregating all computer-related LCAs filed by cap-bound for-profit employers for the 2007 and 2008 lotteries at the metropolitan area level, we then generate the number of cap-bound H-1B applications awarded in each city. The difference provides a measure of the absolute value of the negative supply shock to computer related occupations in metropolitan area $c$ in 2007 and 2008 (combined). The resulting variable $D_c$ takes values that differ across cities due to different shocks. In order to better capture the impact and magnitude of this random shock on the local market, we scale the absolute number $D_c$ by the initial (pre-lottery) total employment in computer-related occupations in 2005/06 (we average the 2005/06 data in the ACS to have a larger and more reliable sample). Hence, our key explanatory variable is the negative supply shock as a percentage of initial employment: $d_c = D_c/Empl_{c,2005/06}$.

Finally, the third database that we use is the 2000 5% Census and the 2005-2011 1% American Community Surveys to construct pre-lottery and post-lottery

measures of the relevant employment and wage outcomes of native and foreign-born workers by city.[34] In particular we select civilian employees age 18-65 who do not live in group quarters, are not enrolled in school, and reside in metropolitan areas. Only those who worked in the previous year, earned positive wages, and are currently employed full time (more than 39 weeks per year and 34 hours worked per week) are included. Annual wage outcomes are converted to real 2010 dollars. By creating average wage and employment data at the metropolitan area level and merging it with our LCA and I-129 data, we can assess whether the random negative employment shocks to local labor markets affected outcomes for natives and immigrants working in those markets.

The dependent variables in our regressions use ACS data to construct the growth in employment and wages for different groups that has occurred for computer-related occupations in metropolitan area c since the period immediately preceding the H-1B lotteries. We choose 2005/06 as our base period. Our decision to merge two years helps us create a more representative and larger sample of cities. We then consider the growth rates of employment and wages one year (2008-2009), two years (2009-2010), and three years (2010-2011) after the lottery shocks obtained cumulating the 2007 and 2008 lotteries. We always average two years to have a more precise measure — in order to track outcomes in the short and medium run.

## CHECKS CONDUCTED ON THE DATA

We rely on the randomness of the lottery results and on the fact that the amount of denied visas was completely unknown to employers before the lotteries, in order to identify the causal effect of a negative foreign labor supply shift on the wage and employment outcomes of native computer scientists. To ensure the integrity of our data, we perform two checks before proceeding to the calculations phase. While we have no reason to believe that the lottery was nonrandom at the employer level, we aggregate across employer cells of different sizes and confirm that enough variation is left in the explanatory variable and that this variation is random. To establish this, we verify that the supply shock is uncorrelated with the growth rate of employment among foreign-born college-educated workers *before* the shocks take place. If this were not the case, the supply shocks would be

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34   These are the only recent years that data is available for metropolitan areas.

correlated with pre-existing trend and would not be random, substantially undermining our results.

Second, we test whether the variation in the lottery results actually does correspond to a change in the post-lottery employment growth of college-educated foreign-born computer-related workers within a city. It is possible that, once denied a new H–1B visa, firms could rapidly lure foreign-born computer scientists away from other firms as possible replacements. They could also seek alternative visas or explore ways to bypass the quota by sub-contracting to a local non-profit lab. That would obviously mean that the denial of H–1B visas would ultimately not have a profound effect on firms, as they would find the foreign-born workers they need elsewhere. To ensure that is not the case, we checked whether the H–1B negative supply shocks were significantly and negatively correlated with the post lottery growth of foreign-born college educated workers in computer-related occupations across cities.

In order to explore these two important facts we estimate the following specification

$$\%\Delta Empl_{c,s-t}^{foreign-college} = b_0 + \beta \cdot d_c + \varepsilon_c$$

The explanatory variable is the normalized negative H–1B shock in a metropolitan area ($c$) for computer-related occupations ($d_c$) as defined above, and derived from the LCA and I-129 data. The dependent variable is the growth of college-educated foreign-born employment in computer-related occupations in a metropolitan area between year $s$ and $t$ derived from ACS.

Appendix Table 1 displays the estimates of the coefficient from specification (1) with the dependent variable calculated over different time periods. When we check that the lottery outcome is uncorrelated with the pre-existing trends in the computer-related occupations across metropolitan areas (Row 1) we set $s = 2000$ and $t = 2005/06$ so that the dependent variable captures the growth of foreign-born college-educated computer-related employment before the lottery. When we check the power of the random shock to predict foreign employment growth after the lottery we consider $s = 2005/06$ as the base period and $t$ represents one of three post-lottery periods. Rows 2 through 4 alternatively explore periods 2008/2009, 2009/2010 and 2010/2011.[35]

To check whether the results in Column (1) are driven by relatively smaller markets whose results may deviate substantially from the norm, column (2) provides the results of a regression that gives more importance to cities that have higher demand for visas. We also want to check whether the results are influenced by the relative intensity by which cities use foreign-born workers. In order to do this, we take the ratio of the demand for visas to college-educated native employment. Because employment among native workers depends on the supply of visas, we use native employment in year 2000, which is less strongly, if at all, affected by future demand for visas. To smooth the impact of outliers, we take the logarithm of the ratio and use the resulting measure to weight observations in the regression in Column (3).

The results are clear and encouraging. While a significant amount of error is certainly present in measuring the exact employment by cell, we see that all specifications (1)-(4) in the first row show no significant correlation of the random lottery supply shock with the growth of foreign-born employment in the city before the lotteries. The point estimates vary quite a bit across specifications, and the standard errors are large, indicating noise in the data. Nonetheless, there seems to be no systematic correlations of pre-lottery foreign employment growth and lottery outcomes, indicating the lottery outcomes are indeed random.

## DETERMINING WHETHER EMPLOYERS FILLED POSITIONS SET ASIDE FOR H-1B WORKERS WITH OTHER FOREIGN-BORN WORKERS AFTER DENIALS

In the body of the report, we reference the fact that employers did not appear to fill jobs that would have been held by H-1B workers with other foreign-born employees. To establish this fact, we once again perform our regressions to check whether the net growth of foreign-born computer industry employment between 2005-2006 (before the lottery) and 2008-2009, 2009/10, or 2010/11 (one, two, or three year after) was negatively affected by the random negative H–1B supply shock. The presence of a significant correlation confirms that employers who were randomly denied the ability to hire as many H-1B workers as they intended in the 2007 and 2008 visa lotteries ultimately were largely unable to use other avenues in our immigration system to sponsor foreign-born replacements.

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35   In the specification with post-lottery changes, we also included the pre-lottery growth of foreign employment as a control. While there was no significant correlation with the lottery outcome, the pre-event variability should be controlled for.

## APPENDIX TABLE 1:

**Percentage Point Decrease in the Growth in the Aggregate Wages of Local, U.S.-Born Workers as a Result of an H-1B Shock Equal to 1 percent of the City's 2005-2006 Computer Employment**

COMPUTER-RELATED OCCUPATIONS ONLY; EVIDENCE ACROSS METROPOLITAN AREAS

| Models Used | Percentage Point Change in Employment Growth Rate | | | |
|---|---|---|---|---|
| | (1) Unweighted | (2) Weighted by Firms' H-1B Demand | (3) Weighted by ln(H-1B Dependence) | (4) Unweighted; Excludes Outlier |
| **Growth Rate Change for Foreign-Born, College-Educated Workers** | | | | |
| 2000 to 2005-2006 | -7.986 | 0.988 | -7.161 | -12.001 |
| | (5.796) | (1.701) | (5.131) | (8.495) |
| 2005-2006 to 2008-2009 | -6.129* | -1.051** | -4.921* | -8.974** |
| | (3.232) | (0.525) | (2.597) | (4.467) |
| 2005-2006 to 2009-2010 | -4.786 | -1.258** | -3.733 | -6.694 |
| | (2.940) | (0.504) | (2.367) | (4.455) |
| 2005-2006 to 2010-2011 | -4.109 | -0.940 | -3.369 | -6.142 |
| | (2.773) | (0.818) | (2.347) | (4.049) |

Note: Each cell displays the estimate of the coefficient on the explanatory variable $d_c$ (the negative H-1B shock) from a different regression with the dependent variable described in the first column. Each of regression includes the pre-lottery trend of the dependent variable. Observations represent metropolitan area characteristics of computer-related occupations. Number of cities ranges from 234-236, depending upon regression. Standard errors, reported in parentheses are heteroskedasticity robust. Specification (1) does not weight cells. Specification (2) weights for the size of firms' demand for H-1B labor in the cell. Specification (3) weights the observations by the logarithm of firms' demand for H-1B labor, normalized by year 2000 native college employment in the cell. Specification (4) omits an outlier (Trenton, NJ). *, **, *** significant at the 10, 5%, 1% confidence level.  Data on employment is from the ACS.

To examine this issue, we once again turn to Appendix Table 1, which shows the regressions we performed to establish this fact. As discussed above, the top row of the table demonstrates that the lottery is random relative to previous outcomes. The remaining rows examine the impact of the H-1B lotteries on the growth in the employment of foreign-born workers in the years after 2005-2006. We explore the impact over 3-, 4- and 5-year horizons (rows 2 through 4). When we check the power of the random shock to predict foreign employment growth after the lottery we consider $s$ = 2005/06 as the base period and $t$ represents one of three post-lottery periods. Rows 2 through 4 alternatively explore periods 2008/09, 2009/10; and 2010/11.[36]

As is demonstrated in the table, the H-1B supply shock significantly affects the growth in foreign employment in a city between 2005-2006 to 2008-2009. A negative H-1B shock in a city equal to one percentage point of the existing employment caused a reduction in employment growth of foreign-born workers in that cell between 1 and 8.9 percentage points. Using the average estimate (around 5) and converting the effect from number of visas lost into number of foreign jobs, as foreign labor accounted for about 1/4 of total computer-related employment, a loss of one H-1B visa implies about one to one and a quarter fewer foreign workers in those occupations. This suggests that firms did not substitute from foreign workers to other sources when they lost an H-1B visa. The effect seems larger if we do not weight cells and if we omit the outlier. Using estimates of column 4, one lost H1B visa caused up to two lost foreign workers to a firm. Every specification, however, demonstrates a significant slowdown in foreign employment growth when employers experience a larger negative shock in the H-1B lottery.

## ESTIMATING THE IMPACT OF H-1B VISA DENIALS ON U.S.-BORN JOBS AND WAGES

The basic regression that we estimate in order to analyze whether labor market outcomes for native-born computer workers were affected by the lottery supply shocks is as follows:

$$\% \Delta y_{c,2005/06-t}^{native,j} = b_0 + b_1 \cdot \% \Delta y_{c,2000-2005/06}^{native,j} + \beta \cdot d_c + \varepsilon_c$$

In (2) the dependent variable $\Delta y_{c,2005/06-t}^{native,j}$ is measured using the ACS data on the growth of outcome $y$ (alternatively employment, wages, or the total wage bill) for native group $j$ (college-educated and non-college educated) in computer-related occupations in metropolitan area $c$ between the base period of 2005/06 and period $t$ (alternatively 2008/09, 2009/10, and 2010/11). The term $d_c$ captures captures the negative H-1B supply shock as a percentage of pre-lottery total computer-related employment, described above, and it is our main explanatory variable. The variation of the term $d_c$ is only driven by the randomness of the lottery. Hence it is reasonable to assume that it is orthogonal to other unobserved determinants of $\% \Delta y_{c,2005/06-t}^{j}$ that are captured by the random measurement error term $\varepsilon_c$. However, our regression also controls for the pre-2006 trend of the dependent variable, $\% \Delta y_{c,2000-2005/06}^{native,j}$. This term is intended to control for past conditions of local labor markets that may have persistent influence. Under these assumptions, the estimated coefficients can be interpreted as the causal effect of the negative supply shocks on U.S.-born outcomes. To account for the fact that the variance of the outcomes and the exogenous regressor can be different in small and large cells, we use robust standard errors and, in some specifications, we weight observations by the size of firms' H-1B demand.

Appendix Tables 2, 3, and 4 show the estimated coefficient, $\beta$, capturing the effect of a negative H-1B supply shock when the outcome is, respectively, the growth of native employment (Table 4), the growth of native wages (Table 5), and the growth of the overall native wage-bill (total wage income to natives, Table 6) in a city since the pre-lottery year 2005/06. We report outcomes for college-educated natives in the upper part of each table and the outcomes for non-college graduates in the lower part. Different rows display the lottery impact on the cumulative growth of the dependent variable since 2005/06 up to years 2008/09 (i.e., one year after the lotteries), 2009/10 (two years), and 2010/11 (three years). The charts can be seen on the following pages.

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36 In the specification with post-lottery changes, we also included the pre-lottery growth of foreign employment as a control. While there was no significant correlation with the lottery outcome, the pre-event variability should be controlled for.

## APPENDIX TABLE 2:

**Percentage Point Decrease in the Growth in the Number of Jobs Available to Local, U.S.-Born Workers as a Result of an H-1B Shock Equal to 1 percent of the City's 2005-2006 Computer Employment**

COMPUTER-RELATED OCCUPATIONS ONLY; EVIDENCE ACROSS 236 METROPOLITAN AREAS

| | Percentage Point Change in Employment Growth Rate | | | |
|---|---|---|---|---|
| **Models Used** | **(1)** Unweighted | **(2)** Weighted by Firms' H-1B Demand | **(3)** Weighted by Firms' (H-1B Dependence) | **(4)** Unweighted; Excludes Outlier |
| **Growth Rate Change for U.S.-Born, College-Educated Workers** | | | | |
| 2005-2006 to 2008-2009 | -1.055 | -0.582*** | -0.971 | -1.118 |
| | (0.978) | (0.167) | (0.896) | (1.633) |
| 2005-2006 to 2009-2010 | -1.059 | -1.031*** | -1.015 | -0.603 |
| | (0.919) | (0.206) | (0.836) | (1.459) |
| 2005-2006 to 2010- 2011 | -0.320 | -1.312*** | -0.403 | 0.920 |
| | (1.389) | (0.288) | (1.296) | (2.007) |
| **Growth Rate Change for U.S.-Born Workers Without Bachelor's Degrees** | | | | |
| 2005-2006 to 2008-2009 | -3.492 | -0.148 | -3.025 | -5.574* |
| | (2.267) | (0.608) | (2.049) | (3.041) |
| 2005-2006 to 2009-2010 | -5.135* | -1.299*** | -4.616* | -7.058* |
| | (2.827) | (0.280) | (2.565) | (4.058) |
| 2005-2006 to 2010-2011 | -4.965** | -0.793*** | -4.456** | -7.154** |
| | (2.273) | (0.214) | (2.064) | (2.985) |

Note: Each cell displays the estimate of the coefficient on the explanatory variable $d_c$ (the negative H-1B shock) from a different regression with the dependent variable described in the first column. Each of regression includes the pre-lottery trend of the dependent variable. Observations represent metropolitan area characteristics of computer-related occupations. Number of cities ranges from 234-236, depending upon regression. Standard errors, reported in parentheses are heteroskedasticity robust. Specification (1) does not weight cells. Specification (2) weights for the size of firms' demand for H-1B labor in the cell. Specification (3) weights the observations by the logarithm of firms' demand for H-1B labor, normalized by year 2000 native college employment in the cell. Specification (4) omits an outlier (Trenton, NJ). *, **, *** significant at the 10, 5%, 1% confidence level.  Data on employment is from the ACS.

## APPENDIX TABLE 3:

### Percentage Point Decrease in the Growth in the Wages of Local, U.S.-Born Workers as a Result of an H-1B Shock Equal to 1 percent of the City's 2005-2006 Computer Employment

COMPUTER-RELATED OCCUPATIONS ONLY; EVIDENCE ACROSS METROPOLITAN AREAS

| Models Used | Percentage Point Change in Growth Rate of Wages | | | |
|---|---|---|---|---|
| | (1) Unweighted | (2) Weighted by Firms' H-1B Demand | (3) Weighted by ln(H-1B Dependence) | (4) Unweighted; Excludes Outlier |
| **Growth Rate Change for U.S.-Born, College-Educated Workers** | | | | |
| 2005-2006 to 2008-2009 | -0.284 | -0.153 | -0.236 | -0.363 |
| | (0.232) | (0.125) | (0.216) | (0.375) |
| 2005-2006 to 2009-2010 | -0.626*** | -0.258* | -0.554*** | -0.789** |
| | (0.214) | (0.144) | (0.189) | (0.311) |
| 2005-2006 to 2010- 2011 | -0.568* | 0.034 | -0.468* | -0.870** |
| | (0.309) | (0.120) | (0.273) | (0.402) |
| **Growth Rate Change for U.S.-Born Workers Without Bachelor's Degrees** | | | | |
| 2005-2006 to 2008-2009 | -0.530* | -0.113 | -0.451* | -0.903*** |
| | (0.287) | (0.134) | (0.262) | (0.317) |
| 2005-2006 to 2009-2010 | -0.303 | 0.100 | -0.249 | -0.620 |
| | (0.293) | (0.187) | (0.274) | (0.400) |
| 2005-2006 to 2010-2011 | -0.189 | 0.016 | -0.172 | -0.230 |
| | (0.277) | (0.163) | (0.257) | (0.466) |

Note: Each cell displays the estimate of the coefficient on the explanatory variable $d_c$ (the negative H-1B shock) from a different regression with the dependent variable described in the first column. Each of regression includes the pre-lottery trend of the dependent variable. Observations represent metropolitan area characteristics of computer-related occupations. Number of cities ranges from 234-236, depending upon regression. Standard errors, reported in parentheses are heteroskedasticity robust. Specification (1) does not weight cells. Specification (2) weights for the size of firms' demand for H-1B labor in the cell. Specification (3) weights the observations by the logarithm of firms' demand for H-1B labor, normalized by year 2000 native college employment in the cell. Specification (4) omits an outlier (Trenton, NJ). *, **, *** significant at the 10, 5%, 1% confidence level.  Data on employment is from the ACS.

## APPENDIX TABLE 4:

**Percentage Point Decrease in the Growth in the Aggregate Wages of Local, U.S.-Born Workers as a Result of an H-1B Shock Equal to 1 percent of the City's 2005-2006 Computer Employment**

COMPUTER-RELATED OCCUPATIONS ONLY; EVIDENCE ACROSS METROPOLITAN AREAS

| Models Used | Percentage Point Change in the Growth Rate of Aggregate Wages | | | |
|---|---|---|---|---|
| | (1) Unweighted | (2) Weighted by Firms' H-1B Demand | (3) Weighted by ln(H-1B Dependence) | (4) Unweighted; Excludes Outlier |
| **Growth Rate Change for U.S.-Born, College-Educated Workers** | | | | |
| 2005-2006 to 2008-2009 | -1.230 | -0.708*** | -1.071 | -1.415 |
| | (1.004) | (0.225) | (0.905) | (1.656) |
| 2005-2006 to 2009-2010 | -1.417 | -1.247*** | -1.292 | -1.084 |
| | (0.883) | (0.263) | (0.796) | (1.418) |
| 2005-2006 to 2010- 2011 | -0.323 | -1.341*** | -0.361 | 0.919 |
| | (1.495) | (0.340) | (1.374) | (2.245) |
| **Growth Rate Change for U.S.-Born Workers Without Bachelor's Degrees** | | | | |
| 2005-2006 to 2008-2009 | -3.332 | -0.131 | -2.886 | -5.482* |
| | (2.191) | (0.670) | (2.041) | (2.964) |
| 2005-2006 to 2009-2010 | -4.609 | -0.996*** | -4.196 | -6.559 |
| | (2.812) | (0.365) | (2.635) | (4.199) |
| 2005-2006 to 2010-2011 | -4.331** | -0.674** | -3.946** | -6.261** |
| | (2.034) | (0.284) | (1.901) | (2.825) |

Note: Each cell displays the estimate of the coefficient on the explanatory variable $d_c$ (the negative H-1B shock) from a different regression with the dependent variable described in the first column. Each of regression includes the pre-lottery trend of the dependent variable. Observations represent metropolitan area characteristics of computer-related occupations. Number of cities ranges from 234-236, depending upon regression. Standard errors, reported in parentheses are heteroskedasticity robust. Specification (1) does not weight cells. Specification (2) weights for the size of firms' demand for H-1B labor in the cell. Specification (3) weights the observations by the logarithm of firms' demand for H-1B labor, normalized by year 2000 native college employment in the cell. Specification (4) omits an outlier (Trenton, NJ). *, **, *** significant at the 10, 5%, 1% confidence level.  Data on employment is from the ACS.